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A STUDY OF THE HEALTH EFFECTS OF VIDEO DISPLAY TERMINALS IN THE WORKPLACE

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Department of Labor and Industries
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Division of Occupational Hygiene
Richard Levine, Director

A STUDY OF
THE HEALTH EFFECTS OF
VIDEO DISPLAY TERMINALS
IN THE WORKPLACE

COMMISSIONED BY THE MASSACHUSETTS LEGISLATURE JULY, 1984

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Executive Office of Labor

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I N T R O D U C T I O N

INTRODUCTION

The following document reports the results of a study of the health effects of video display terminals in the workplace conducted by the Division of Occupational Hygiene, Department of Labor and Industries. It was commissioned by the Commonwealth of Massachusetts Legislature in 1985.

It is estimated that there are over 12 million video display terminals (VDTs) currently in use in the United States, and that by 1990, the number of VDTs will increase at least five-fold up to 60 million or more. Concerns about a number of adverse health effects have been reported by VDT operators since the introduction of terminals into the workplace; these include health conditions related to vision, muscle pain, headaches, symptoms of stress, and concerns regarding reproductive hazards and birth defects. Investigations have been conducted by both private and public agencies to help determine if there is an association between the reported health effects and the use of VDTs.

A. BACKGROUND

In testimony on the health issues of VDT use to the Subcommittee on Health and Safety of the United States House of Representatives

Committee on Education and Labor, Dr. J.D. Millar,(1984), Director of the National Institute for Occupational Safety and Health (NIOSH) indicated the scope of the problem by stating:

> In my lifetime, no innovation has had so sweeping a change on American society as the computer. Had we predicted 10 years ago, the degree to which American office work would now be computerized, nobody would have believed us---VDT represents a medium through which American life is being drastically and irrevocably changed. No one can accurately predict all the social ramifications of this change.

This testimony was part of extensive hearings conducted by the House Subcommittee on Health and Safety. Testimony was also given by representatives from the fields of manufacturing, business and industry, labor, medicine, opthalmology, human factors engineering and research. The major concerns expressed in these hearings published in a preliminary report in August, 1985 included radiation hazards, reproductive hazards, vision problems, and ergonomic issues.

ORGANIZATION OF STUDY

Staff members of the Division of Occupational Hygiene were given responsibility to develop and conduct the study within the fiscal year. Because of the complexity of the tasks, services of an epidemiologist were obtained. The epidemiologist worked with the staff to design the study, to plan the analysis and to oversee the statistical and epidemiological aspects. Six research assistants were also employed on a part-time basis to assist with the field surveys, data collection and data management.

It was first necessary to ask what could be expected to be learned from such a study; i.e. What specific hypotheses would be evaluated? What are the important factors that need to be considered? Are there specific adverse health effects associated with office work and in particular with the use of video display terminals? Would the same adverse health effects be found among office workers who do and do not use VDTs? How does the general office environment affect office workers? Are there radiation hazards associated with the use of VDTs? What ergonomic factors need to be considered? Would the number of continuous hours on a terminal have any effect on the health of an individual worker? Would the age of the workers or his/her educational preparation be an influencing factor? What other variables need to be considered in the development of the study?

B. REVIEW OF LITERATURE

To answer some of these questions, a review of the literature was conducted to determine what information on VDTs was available, to learn what studies have been conducted and what questions remain unanswered. A thorough review of the literature indicated that most of the studies had been conducted in Europe in the early 1970's, primarily in Sweden and Germany. In comparison, there have been few studies conducted in the United States.

A summary of these early studies and their findings was reported

by M.J. Smith (1981), at the National Institute of Occupational Safety and Health (NIOSH) in Health Issues In VDT Work:

> In summary, interest in VDTs in Western Europe originated and has remained centered mainly on ergonomic design issues of the work environment and workstation, and how these influence worker visual and muscular complaints. In the United States initial concerns focused on potential radiation health hazards, but in the last three years have shifted away from radiation to the ergonomic concerns expressed in Europe. . .

Ergonomics, a term that has become popular in recent years, is a science that applies to the multiple interacting factors between people and machines. Snook, Project Director for Ergonomics at the Liberty Mutual Occupational Safety and Health Research Center in Massachusetts reported that "ergonomics in the U.S. is often called human factors - and is very simply defined as designing the job to fit the worker." He further reported that the goal of ergonomics in industry is to increase productivity and decrease injuries and illnesses, by obtaining a good match or fit between the worker and the job. In relation to VDTs, ergonomics is generally related to physical factors in the work environment, such as tables, chairs, terminal screens, and lighting and how these factors can affect the workers' health and comfort.

Other U.S. studies were conducted by Dainoff (1982), Stammerjohn et al. (1981), Arndt (1983), and Sauter (1984), in which measurements were taken of VDT operators and workstation interactions to examine the correlations between health complaints and these measurements.

In 1980, an international scientific workshop was held in Milan, Italy on the ergonomic and medical aspects of VDT workplaces. Representatives from Europe, Japan, Australia and the United States presented reports of studies on these issues. The proceedings of this workshop were published in a text edited by leaders in the field, Grandjean and Vigliani (1983).

Smith (1981), also reported that NIOSH has taken a leading role in examining VDT health issues in the United States. He indicated that the body of knowledge in this area has a number of weaknesses and that additional research is necessary to more fully understand the problems and to present solutions. He believed there is a need to study chronic health effects of VDT work as well as further field studies of acute health and performance effects of VDT work. Current studies he reported, suffer from inadequate VDT operator samples, poor control groups, poor response rates and other possible sources of inaccuracy. Smith concluded that highly controlled field studies of large VDT operator populations and controls are needed and these studies require the cooperation of industry, labor, educational institutions and government.

An analysis of the research literature of the existing studies of visual complaints associated with VDT use was conducted and reported by the National Research Council (1983). The Council reported that much of the literature has been based on a small number of studies and that inferences reasonably drawn from them are suggestive rather than conclusive. Surveys have not established

whether complaints and reported symptoms are related to VDT characteristics, other aspects of the workplace and job situation, or some combination of these factors. The NRC final conclusion was that carefully designed research on the effects of VDT characteristics on visual performance and comfort would be useful.

Tuthill (1985), an epidemiologist at the University of Massachusetts at Amherst, under contract to the Commonwealth of Massachusetts submitted a review of the literature to the Governor entitled "Assessment of the Literature on Health Effects Related to Video Display Terminals." This review of the literature focused on the health issues associated with reports of harmful emissions from the VDT itself and with ergonomic problems related to VDT use. Tuthill mentioned the uncertainties in the current knowledge on the reported health hazards associated with the use of VDTs. He was critical of some of the study methodology, such as the low response rate on questionnaires, possible over-reporting of symptoms by workers who already had heightened concerns about their symptoms, and the lack of adequate control groups (non-VDT users).

It was noted in the review of the literature that there is a wide range of opinions by investigators on the subject of potential health hazards associated with the introduction and growth of video display terminals in the workplace. A few studies found there is no scientific evidence to support an association between VDT operators and reported health complaints. Other investigators report that

although the exact cause has not been determined, there are visual, musculoskeletal and emotional or psychological symptoms that can be related to the use of VDTs.

Some investigators suggested that clerical workers are at higher risk of developing adverse health conditions related to vision, musculoskeletal symptoms, colds, sore throats and headaches than other workers who use VDTs but who have more diversity and control of their job tasks, such as computer programmers. A few investigators reported that although health complaints were voiced, the health conditions reported were of little or no consequence, representing annoyances or minor discomforts. The type of VDT work, that is, data entry, data acquisition, or conversational mode or word processing, was identified as having an influence on the incidence and prevalence of visual symptoms among operators.

Other variables and interacting factors that were mentioned as having an influence on health conditions included the length of work periods without breaks, job control, job satisfaction as well as environmental and ergonomic factors. In general, almost all of the investigators recommended the need for additional research to identify more fully the causal factors of the acute adverse health effects reported among VDT operators as well as to identify any long-term chronic health conditions related to VDT use.

After a review of these studies and given the limited time frame of this study, it was decided by the study group that the present

study should focus on the health effects of the group reportedly at highest risk, the clerical workers; and the study would focus on health conditions related to vision, musculoskeletal system, headache, colds or sore throats and stress. From the review of the literature it was recognized, both because of cost and time factors, that issues related to reproductive hazards and birth defects would need a comprehensive study and could not be evaluated within the scope of this study.

M E T H O D O L O G Y

A. QUESTIONNAIRE DEVELOPMENT

The next step in the development of the study was to select a data collection method which would evaluate the level of health complaints among office workers and to investigate the relation between these complaints and the use of VDTs. It was agreed that a health questionnaire would be the most appropriate method in terms of getting the most information from the largest number of participants within the allotted time frame for the study.

The results of the questionnaire would be analyzed in connection with industrial hygiene data (temperature, humidity and carbon dioxide levels) and with the type of office work (typist, word processor, telephone operator, etc.) to compare how frequently health conditions are reported by office workers who use VDTs with how frequently health conditions are reported by those who do not use VDTs.

To write an effective, questionnaire, sample questionnaires and surveys were obtained from NIOSH, Women's Occupational Health Resource Center, Utility Workers Union of America, and 9to5, the National Association of Working Women. In addition, surveys that deal only with stress and psychological strain were collected; these included the Profile of Mood States, Derogatis Stress Profile, and materials developed by noted authorities, Dr. Lyle Miller of Boston University School of Medicine and Dr. Robert Karasek formerly at Columbia University and currently at the University of Southern

California, Los Angeles. From these sources and independent research, a new questionnaire was written to collect information on five main sets of health conditions (visual, musculoskeletal, headache, cold or sore throat and stress) and any underlying conditions that could affect those systems.

The questionnaire and industrial hygiene data forms that were developed were then pilot tested in a group of approximately 150 office workers. Preliminary meetings with supervisors were held, the questionnaire was administered, office layout was mapped and air quality measurements were taken. Pilot testing and follow-up discussions were held to elicit comments regarding the readability and acceptability of the questionnaire. The results were coded and analyzed, specifically to assess the questionnaire's quality.

The questionnaire was revised to incorporate the changes indicated by this pilot testing process. The final questionnaire developed consisted of a ten-page document containing sections on demographic factors, current and pre-existing medical conditions, stress factors, nature of work activities, job satisfaction, job control, and frequency of symptoms related to vision, musculoskeletal conditions, headaches, colds or sore throats. (Appendix III).

B. SELECTION OF THE SAMPLE: SITES AND SUBJECTS

To obtain a representative sample of Massachusetts clerical workers who use VDTs, the Standard Industrial Classification Codes

were reviewed to determine the industries that were most likely to use VDTs in their operations and employ a high percentage of VDT clerical workers. The seven industries selected and identified by SIC code were banking (60), communications (48), computers and data processing services (737),hospitals (806), public utilities (49), insurance (63) and securities and commodities (62). It also seemed appropriate to include the Commonwealth of Massachusetts as a representative of the public employer.

To obtain a representative sample, sites were selected at random from a list of Massachusetts employers of fifty (50) or more workers. Recognizing that there may be differences between large and small size industries, sites were selected within categories of industry size according to the number of employees (50-99, 100-249, 250-499, 500-999, and 1000 or more employees).

When the sample was selected, a letter was sent to the president of each selected company describing the nature of the study, and requesting participation. (Appendix I). To prevent possible over-reporting of symptoms by VDT operators, the study was presented as a general study of the health of office workers and not as a study of the health effects associated with VDT use. The letter was followed in a few days by a telephone call to arrange a convenient time either to meet with a company representative for further discussion of the study, or to conduct the walk-through survey and administer questionnaires to employees. Participation by individual

employees in completing the questionnaire was voluntary and all information collected from individual participants kept strictly confidental. Companies that initially refused to participate in our survey were approached again later. It was important to keep the refusal rate low in order to obtain a representative sample of clerical workers.

The study was conducted at thirty-eight (38) work sites in Massachusetts. Questionnaires were administered to 2119 office workers. The final participation rates for the work sites in each industry group were as follows: 100 percent from banking, hospitals and the Commonwealth of Massachusetts; communications 80 percent; public utilities 71 percent; and computer and data processing services 67 percent. Although the participation rate in the Communications industry was 80 percent, the largest employer, representing approximately 60 percent of employees in this group in Massachusetts did not participate in the study. Furthermore, the insurance industry was excluded from the data analysis because the low participation rate of 43 percent among companies contacted suggested that the data for this industry group might contain high degree of bias.

Individual study subjects from each site were selected according to the following guidelines: All clerical workers were included in the study for sites employing few such workers. For larger sites, the goal was to include no more than two hundred (200) workers with

approximately one-third of these workers in positions that do not involve VDT use, one-third in the high VDT use category (seven or more hours per day), and the remaining one third workers who use VDTs between one-half and six hours per day. The particular subset of eligible workers included in the study was determined at random by first selecting floors or departments, and then rooms of workers. Overall, we attempted to study approximately 300 subjects in each industry category. The participation rates for workers ranged from 94 percent to 99 percent.

To achieve participation rates sufficient for a valid study, personnel were assured that all data collected pertaining to the particular businesses and industries participating in the study are strictly confidential, including the names of businesses, names of participating office workers, and results that could in any way link particular findings to particular employers and employees.

C. DATA COLLECTION

Following a walk-through survey of the work site to select subjects, either the study group or the industry supervisor explained the general nature of the study (a general survey of the health of office workers) to the clerical workers selected for study and requested their voluntary participation. Each worker who agreed to participate was given the questionnaire to complete at the worksite. Approximately 15 to 30 minutes were required to complete the

questionnaire.

The questionnaire sought information pertaining to the worker's age, educational level, the nature of his/her job, the presence of pre-existing health conditions that could modify the frequency of the evaluated outcomes such as : arthritis, back or neck injury, visual conditions, musculoskeletal conditions, headaches, and colds or sore throats.

Questions concerning the frequency of vision and musculoskeletal conditions, headache, and colds or sore throats asked respondents how often during the past two months each condition had been experienced. The check list of answers was as follows: almost always (= four or more times each week), frequently (= about one time each week), occasionally (= about one time each month), or not at all (= not at all) during the past two months. For the sections of the questionnaire probing vision and musculoskeletal conditions, an additional question asked whether any of the vision or musculoskeletal conditions had been severe enough to cause the respondent to miss work during the past two months.

The questions pertaining to the nature of the job asked for the usual number of hours worked each day with a typewriter, a switchboard, a keyboard machine with a visual display screen (VDT, CRT, word processor, or computer terminal), a copier, an adding machine, and other desk work.

While the participants were completing the questionnaires at the

worksite, the survey team measured room temperature and relative humidity by means of a sling psychrometer. Temperature and humidity are important components of comfort ventilation. Health conditions, such as "burning, itching eyes" may be associated with high temperature and low relative humidity. Low humidity has also been associated with drying of mucous membranes leading to increased colds, viral infections and other respiratory symptoms.

Carbon dioxide measurements were also made using the GasTech infrared CO_2 meter as a measure of air quality. In occupied spaces, carbon dioxide from exhaled breath tends to build up when enough fresh air is not present to control it. When the fresh air supply is low, occupants may experience symptoms such as headaches, dizziness, eye and throat irritation, respiratory difficulties and even nausea. (DOH Form #317; Hicks, 1984; Taylor, 1984; Thoburn, 1984; ASHRAE 62-1981).

Descriptive data were collected also at this time on the total number of people in the room, the number of VDT and non-VDT operators, and the number of occupants who were cigarette smokers in the room.

D. DATA ANALYSIS:

The data were summarized for analysis using the DEC 10 mainframe computer at Tufts University, Medford and the 1022 software statistical analysis program. The data analysis involved estimation

of the prevalence ratio (the prevalence of health conditions among VDT users divided by the prevalence of health conditions among non-VDT users) and associated confidence limits, using the method proposed by Miettenen (1974, 1976), as described by Rothman and Boice (1979).

After the data were collected and coded, grouping of the information into various categories was required to assist in the analysis of whether the number of hours of VDT use daily was associated with health effects. Data to be analyzed were grouped by industry, hours of VDT use and health outcomes.

The first grouping is by industry. All questionnaires were identified by the employing company and the room in which the respondent worked. Differences among industries could be documented because all clerical workers, be they VDT users or not, are identified by the location code of their employer. If hours of VDT use do not have an impact on the evaluated health conditions, and type of industry does, then it would be expected that all employees in an industry would report similar levels of health complaints and that this level of complaint is different than the level of health complaints in another industry. In fact, for two of the health outcomes (musculoskeletal problems and headaches), industries fell into two different categories.

Second, because clerical workers may use VDTs all day at work, for some portion of the day or not at all, it is necessary to group

the hours of VDT use into categories. The categories selected were: 0 hours (those who circled no VDT use per day); 1/2 to 3 hours (those who circled 1/2 - 1, 2, or 3 hours of VDT use per day: 4 to 6 hours (those who circled 4, 5, or 6 hours of VDT use per day); and 7 or more (those who circled 7 or 8+ hours of VDT use per day) on his/her questionnaire.

Next, it was necessary to define the health effect to be analyzed. The negative health outcomes associated with VDT use that were being evaluated in the study were: vision or eye condition, musculoskeletal discomfort, stress, headache and cold or sore throat.

Clerical workers were asked to indicate the frequency and severity of five visual symptoms and seven musculoskeletal symptoms. For example, question 12, that queried visual symptoms, asked the following:

12. Please check the answer that best describes how often during the past two months that you have experienced the following conditions, according to the meanings below.

MEANINGS: Almost always: Four or more times each week
Frequently: About one time each week
Occasionally: About one time each month
Not at all: Not at all during the past two months

CONDITIONS	ALMOST ALWAYS	FREQUENTLY	OCCASIONALLY	NOT AT ALL
A Eyestrain or sore eyes	_____	_____	_____	_____
B Blurred vision	_____	_____	_____	_____
C Tearing or itching eyes	_____	_____	_____	_____
D Burning or irritated eyes	_____	_____	_____	_____
E Redness of eyes	_____	_____	_____	_____

In addition, respondents were asked to indicate if the condition reported was severe enough to cause the clerical worker to miss work.

The respondents who reported experiencing symptoms "almost always" or who missed work were labeled "cases". In other words, "cases" had the most serious or disabling discomfort. The analysis was aimed at answering the question: are there more "cases" among clerical workers who work on VDTs than among clerical workers who do not work on VDTs. If there are, then it could be concluded that VDT use is associated with an increase in certain symptoms. For vision, a respondent was defined as a case if "almost always" or "missed work" was checked for any of these conditions: eyestrain or sore eyes; blurred vision; tearing or itching eyes; burning or irritated eyes; or redness of eyes. For musculoskeletal conditions, a respondent was defined as a case if "almost always" or "missed work" was checked for any of these conditions: neck pain, stiffness or soreness; shoulder pain, stiffness or soreness; lower back pain; upper back pain; arm pain, stiffness or soreness; pain in hands, fingers or wrists; or numbness or tingling in hands.

An exposure has been defined and grouped: hours of VDT use. An outcome has also been defined: vision, musculoskeletal, headache and cold or sore throat symptoms occurring almost all the time and/or causing missed work. The measure of outcome frequency is called (period) prevalence. Prevalence is a measurement of the proportion of people in a population who have the outcome of interest at or over

a given period in time. This measure is influenced by the number of new cases and by the length of time that symptoms persist. The questionnaire requested information about the frequency and severity of symptoms "during the past two months."

In this cross-sectional epidemiological study, we assessed the prevalence of vision, musculoskeletal, headache, and cold or sore throat cases among 1,545 clerical workers. Thus, we could compare the number of people experiencing serious discomfort among both VDT and non-VDT clerical office workers. The prevalence expresses that number as a fraction of the number of people queried. For example, if 47 out of 359 workers who do not use VDTs are vision cases, then the prevalence of vision cases may be expressed as 0.13 (47 divided by 359). Then, even if there are different numbers of respondents in each category of VDT use, the prevalence of cases may be compared directly. Prevalence may be thought of as percentage; a prevalence of 0.13 is the same as saying 13% of those studied.

Once the prevalence is calculated for each group, comparisons can be made among the groups. Clerical workers who do not use VDTs constitute the comparison or unexposed (non-VDT) group. Each prevalence is compared to the prevalence in the unexposed group. If hours of VDT use have no impact on the frequency of the evaluated symptoms, then the prevalence should remain approximately the same among unexposed and exposed groups and the prevalence rate will be close to 1.0. If the prevalence of symptoms goes down with VDT use,

then it could be hypothesized that VDT use is associated with a decreased frequency of discomfort. Conversely, if the prevalence of symptoms goes up, it can be postulated that VDT use could cause an increase in the freqency of discomfort. This is the method used in the results section to summarize the data.

In tables 1, 3, 6, and 7, the fourth column expresses the comparison as a prevalence ratio. The denominator of each fraction is the prevalence of cases in the unexposed group. The numerator is the prevalence of cases in the group described. A prevalence ratio of 1.0 indicates an equal prevalence in the group considered and in the unexposed group. A prevalence ratio less than 1.0 indicates a lower frequency of cases in the VDT use group. A prevalence ratio greater than 1.0 indicates a higher frequency of cases in the VDT use group.

Part of the fourth column gives the 90% confidence interval for each estimated prevalence ratio. The 90% confidence interval expresses the range of values for the prevalence ratio that is consistent with the data, given a 90% level of confidence.

In evaluating the hours of VDT use as an exposure, it is possible that other variables could affect the results (that is, could "confound" the estimated prevalence ratios). Statistical methods were used to assess the impact of the following variables: age, cigarette smoking, industry, whether or not respondents attended an educational VDT training class prior to this survey, and whether

or not respondents wore glasses or contact lenses. The statistical method stratifies data into different categories for each of the above-named variables, and then estimates the prevalence ratios for each category and overall.

RESULTS

A. DEMOGRAPHIC CHARACTERISTICS

The first data to be analyzed were the demographic characteristics of the subjects. This information describes who was studied, in terms of age, sex, nationality and education level. It was necessary to ascertain if the workers evaluated constituted the group "clerical workers" chosen for study.

Literature prepared by the U.S. Department of Labor, Office of the Secretary, Women's Bureau (1985) indicates that women are "an overwhelming majority of office workers -- workers in the occupation group identified as 'adminstrative support, including clerical'." The statistics in their pamphlet, "Women and Office Automation: Issues for the Decade Ahead," show that 80 percent of all workers in this category (1984) were women. In certain job categories their proportional representation is even higher: 98 percent of all secretaries, stenographers and typists; 89 percent of information clerks; 90 percent of workers who process financial records and 93 percent of telephone operators.

The same pamphlet notes:

> Secretarial pay is based mainly on seniority. The length of time with an employer has more impact on salary than skills used, education, or even job title. For example, while the lack of a high school diploma costs a secretary approximately $2,500 a year, a master's degree adds only $1,500 to the average salary. (U.S. Department of Labor, 1985)

Given that advanced educational training does not translate into higher earnings, there is little in clerical work to attract those

with college degrees. It would therefore be expected that the education level might be relatively homogeneous: high school or junior college.

The Department of Labor reports that minority women hold eleven percent of office and clerical jobs nationally, with proportionally more minorities concentrated in centralized "back office transaction environments."

Results from the present study indicated that the median age of the 1,545 subjects was 34.5 years and the range was from 17 to 72 years. Eighty-five percent were females. Eighty-eight percent of the subjects were White, eight percent were Black, and four percent were Hispanic, Asian, or of another ethnic/racial background.

The highest school level completed was high school or junior college for 84 percent of subjects (57 percent reported high school and 27 percent reported junior college).

These values indicate that questionnaires were distributed to the clerical workers targeted for study.

One industry's set of questionnaires was eliminated from the analysis based on demographic analysis. Questionnaires from securities and commodities indicated that employees in entry level office jobs were actually systems analysts, stocks and bonds sales personnel, executive secretaries, etc. with educational levels of college and graduate school.

Thus, although more than 2,000 questionnaires were collected,

three categories of questionnaires were eliminated from analysis: (1) individual managers, supervisors, and professionals; (2) questionnaires with missing information of daily VDT use; and (3) questionnaires from SIC code (62), securities and commodities, and questionnaires from SIC code (63), insurance. The remaining total of 1,545 questionnaries were suitable for analysis.

B. CONDITIONS RELATED TO VISION

Table 1

Table 1 (page 27) shows the number of office workers, prevalence, and prevalence ratios of vision cases by category of daily video display terminal (VDT) use. These results are for all industries combined. There were no large differences in the estimated prevalence rates of vision cases among the industry groups studied.

Graph 1 (page 28) shows the percentage of vision cases by category of daily VDT use. Prevalence rates have been converted to percentages in all the graphs to facilitate reading of the graphs.

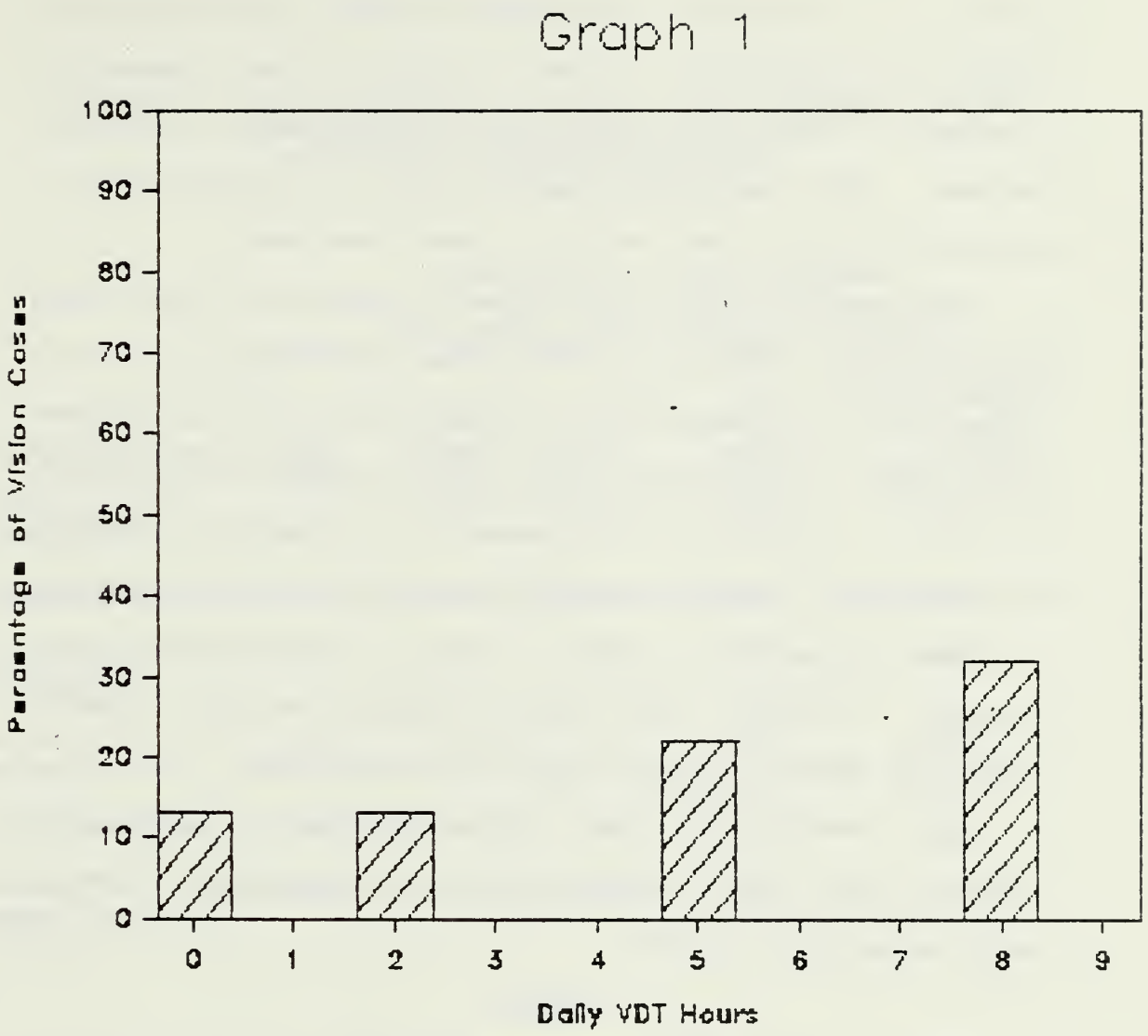
The results indicate that workers who used VDTs 1/2 to 3 hours per day reported the same level of vision cases as those who did not use a VDT at all. There was neither an increase, nor a decrease in the prevalence of cases. (Even though the number of workers in the groups is different, the prevalence of cases is equal).

Clerical workers who used VDTs 4 to 6 hours per day, however,

TABLE 1

Number of Workers, Prevalence, and Prevalence Ratios of Vision Cases Among Office Workers by Daily Video Display Terminal Use in All Six Industries

Daily Video Display Terminal Use (Hours)	Number of Workers	Prevalence of Vision Cases	Prevalence Ratio of Vision Cases (90% Confidence Interval)
0	359	0.13	1.0 -
1/2 - 3	411	0.13	1.0 (0.7 - 1.3)
4 - 6	251	0.22	1.6 (1.2 - 2.2)
7 or more	399	0.31	2.4 (1.9 - 3.0)



Graph 1: Percent of vision cases among office workers in all six industries by daily video display terminal use

reported an increased prevalence of adverse vision conditions compared to workers who did not use VDTs at all. Comparing a prevalence of 0.22 to a prevalence of 0.13 shows a 60 percent increase. The confidence interval (1.2 - 2.2) shows that it is unlikely that this increase reflects a chance occurrence.

Even more striking is the increased prevalence of vision cases among clerical workers who use VDTs seven or more hours per day (the highest level of exposure). The prevalence of 0.31 is 2.4 times higher than the prevalence among clerical workers who do not use a VDT at all. This may also be expressed as a 140 percent increase in the prevalence of cases among those with high VDT exposure, compared to those without VDT exposure. None of the prevalence ratios presented in Table 1 was altered markedly when the potential confounding factors (listed on page 21) were controlled.

These results follow what may be described as a dose-response curve: as the level of exposure increases, the frequency of adverse health outcome also increases.

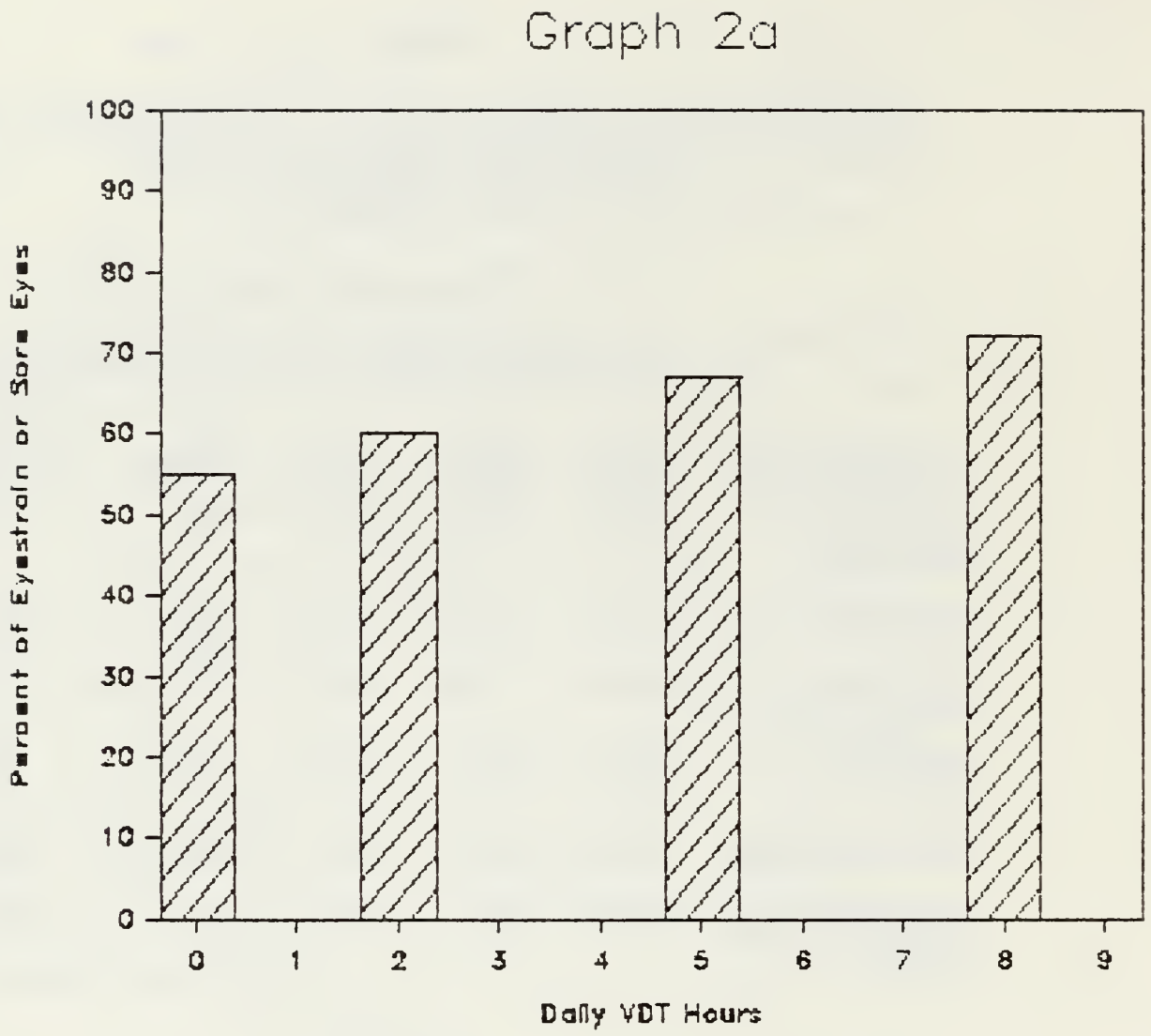
Table 2

Table 2 (page 30) shows the prevalence of vision conditions among the 276 workers labeled "cases", according to the category of daily VDT use. The purpose of this table is to examine which symptoms were reported by those workers who reported vision symptoms as occurring almost always or causing missed work. This table describes only that small subset of workers (276/1545 = 18 percent)

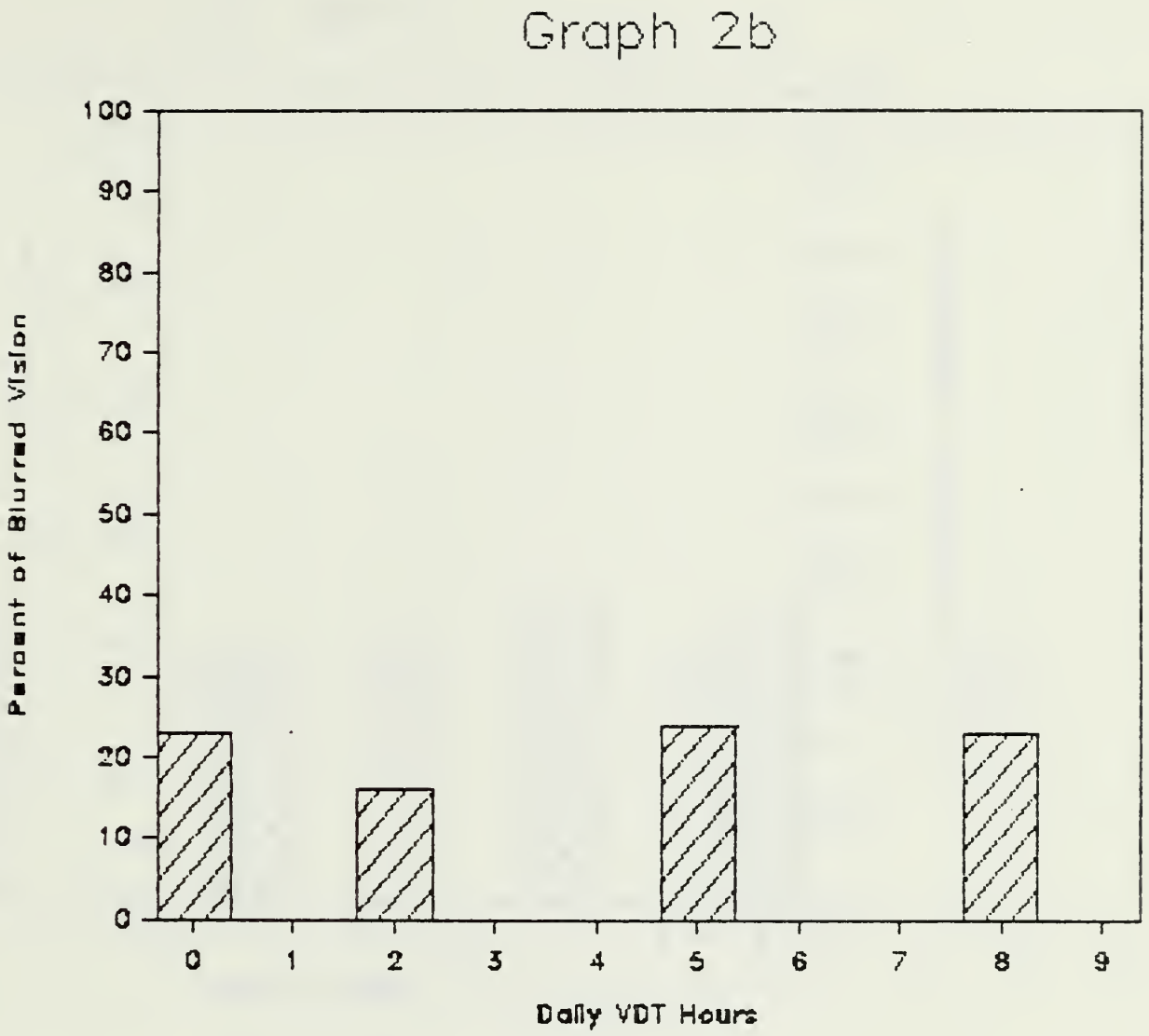
TABLE 2

Prevalence of Vision Conditions Reported as Occurring Almost Always or Causing Missed Work Among Vision Cases by Daily Video Display Terminal Use in All Six Industries

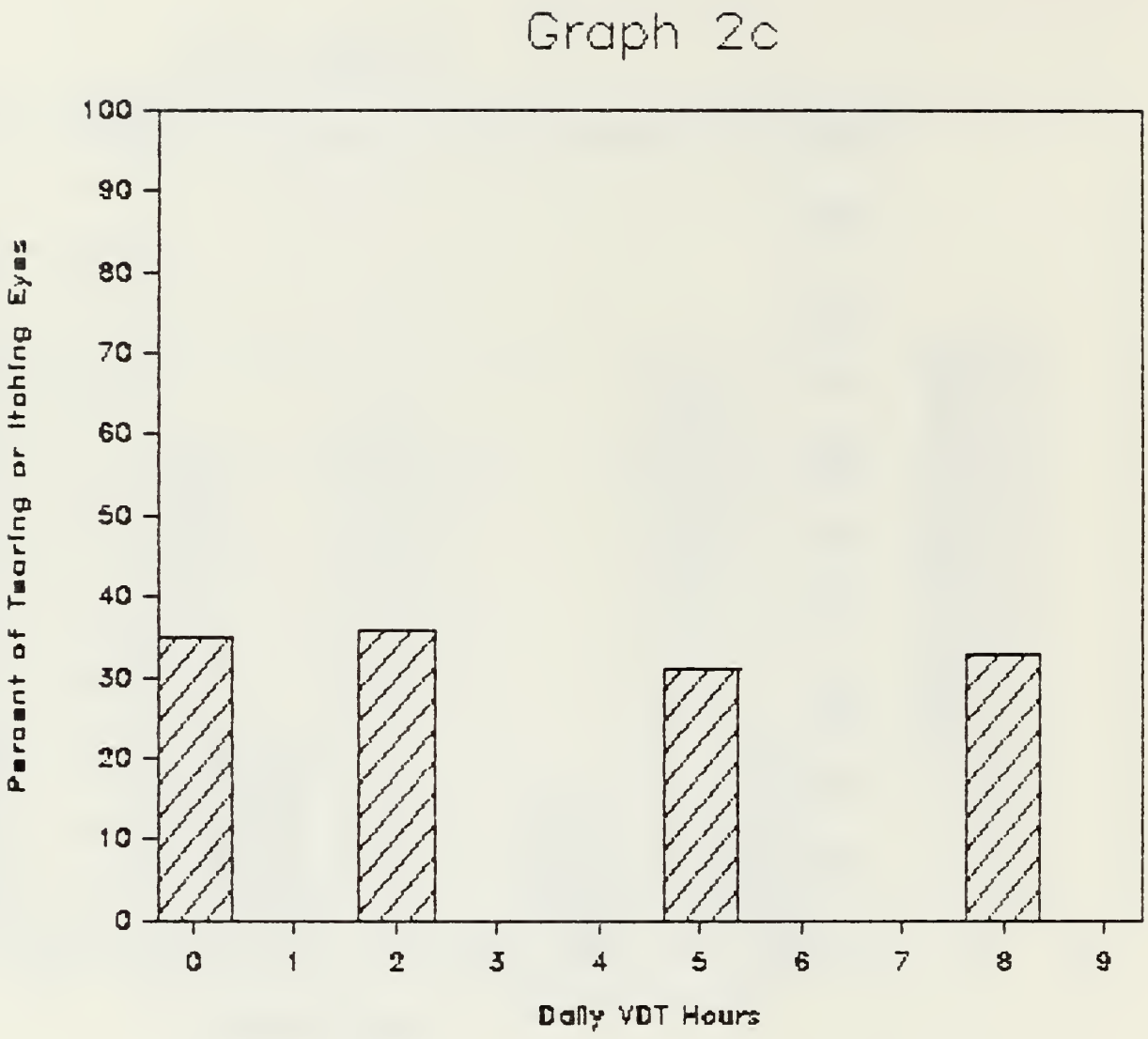
	Prevalence of Vision Condition				
	Daily Video Display Terminal Use (Hours)				
Vision Condition	0 (N=47)	1/2-3 (N=52)	4-6 (N=54)	7 or more (N=123)	All Categories of use (N=276)
Eyestrain or Sore Eyes	0.55	0.60	0.67	0.72	0.66
Blurred Vision	0.23	0.16	0.24	0.23	0.22
Tearing or Itching Eyes	0.35	0.36	0.31	0.33	0.33
Burning or Irritated Eyes	0.33	0.36	0.35	0.36	0.35
Redness of Eyes	0.25	0.29	0.25	0.33	0.29
Missed Work Because of Vision Condition	0.02	0	0.02	0	0.01



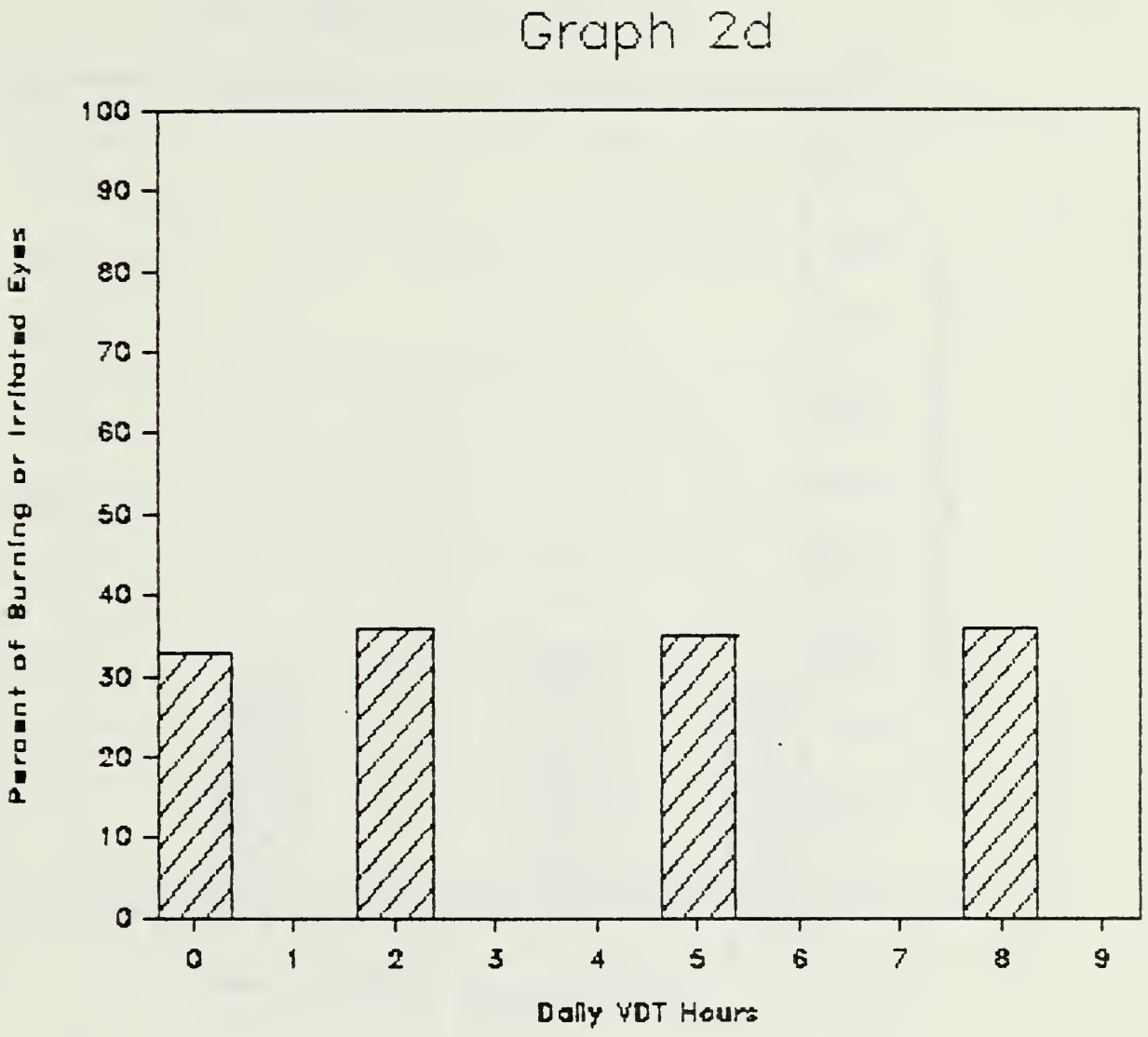
Graph 2a: Percent of vision condition, <u>eyestrain or sore eyes</u>, reported as occurring almost always or causing missed work among vision cases by daily video display terminal use



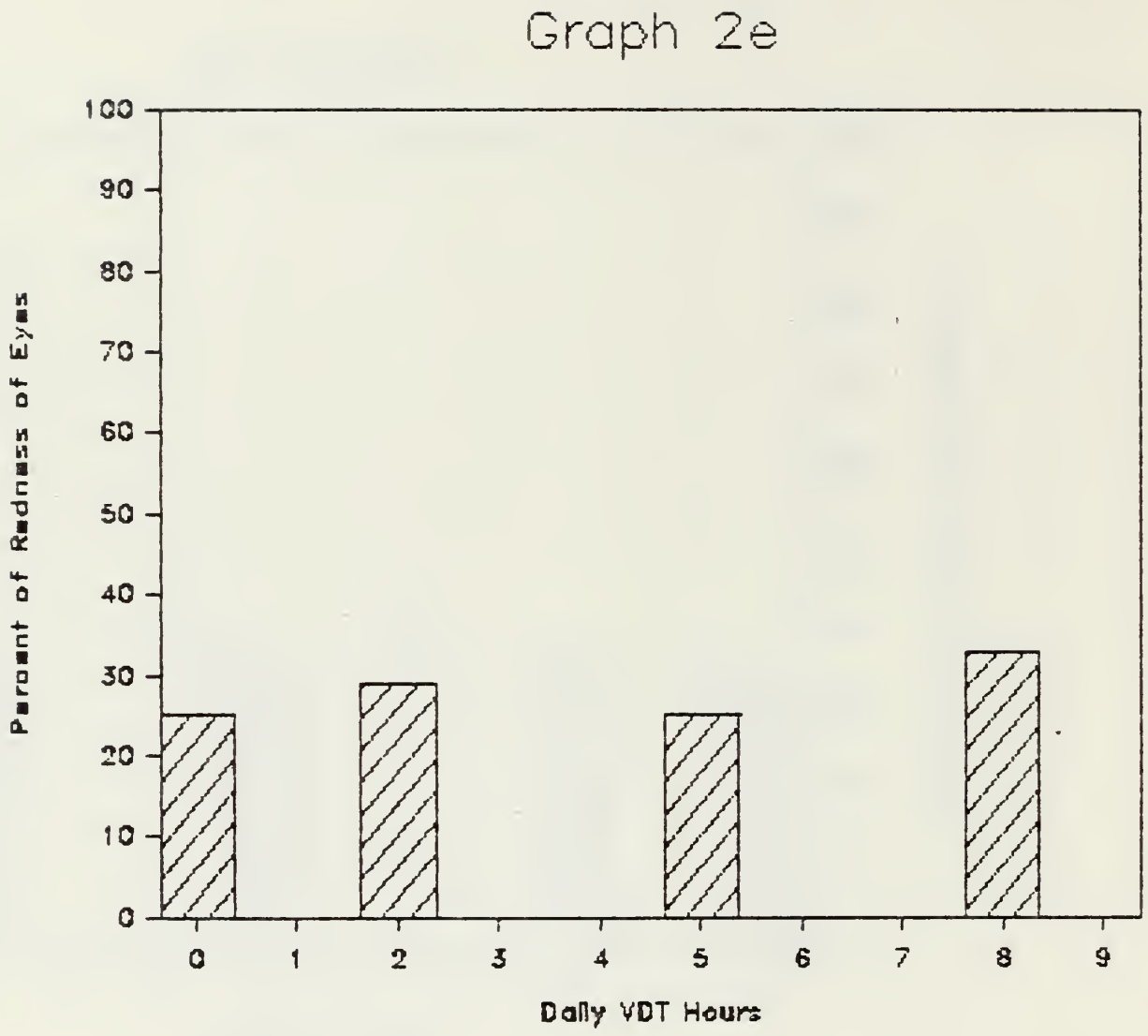
Graph 2b: Percent of vision condition, blurred vision, reported as occurring almost always or causing missed work among vision cases by daily video display terminal use



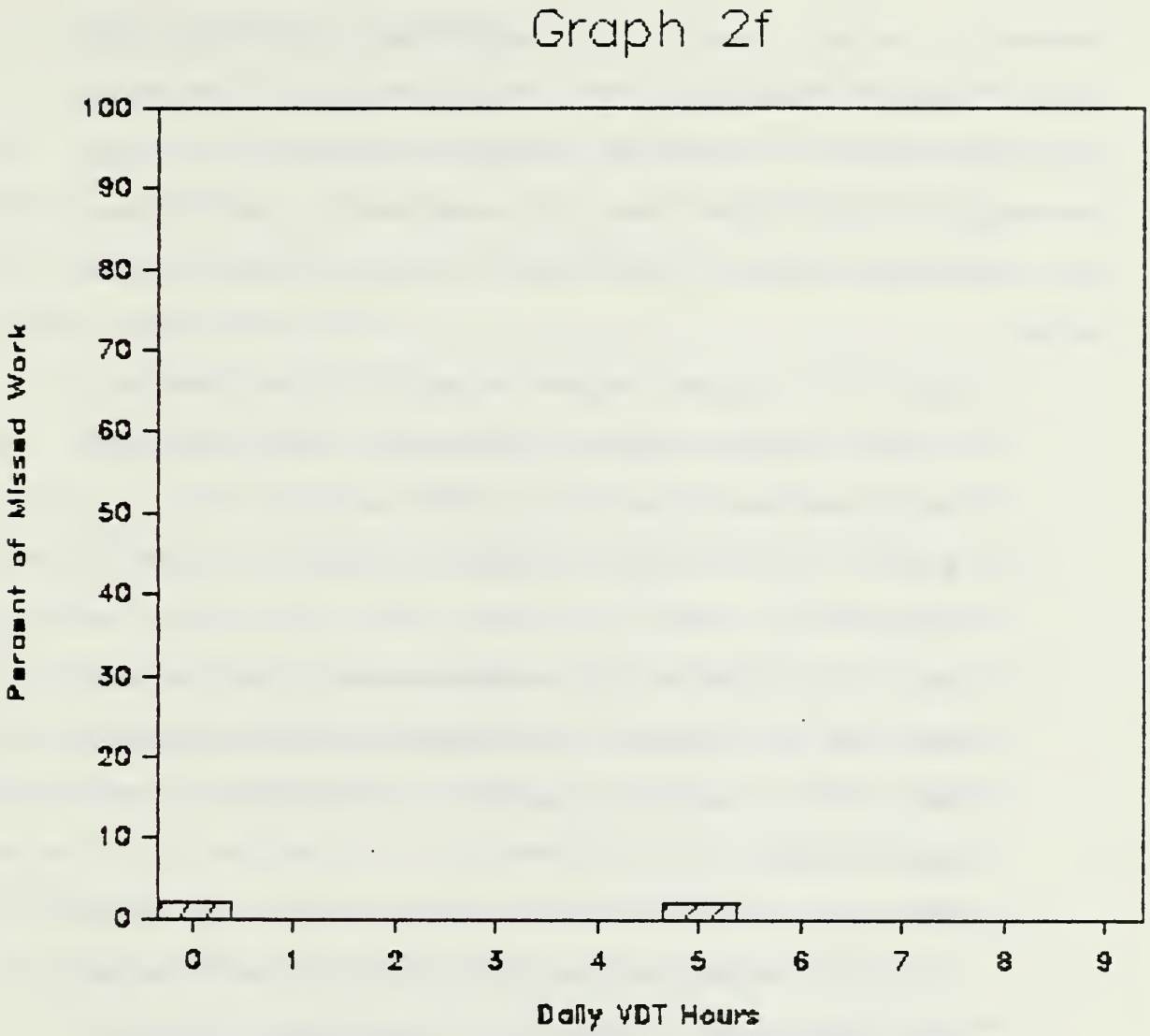
Graph 2c: Percent of vision condition, tearing or itching eyes, reported as occurring almost always or causing missed work among vision cases by daily video display terminal use



Graph 2d: Percent of vision condition, burning or irritated eyes, reported as occurring almost always or causing missed work among vision cases by daily video display terminal use



Graph 2e: Percent of vision condition, redness of eyes, reported as occurring almost always or causing missed work among vision cases by daily video display terminal use



Graph 2f: Percent of vision condition, missed work because of vision condition, among vision cases by daily video display terminal use

representing vision "cases". The percentages do not sum to 100 percent because a case is included in the table once for each vision condition reported. Graphs 2A through 2F (page 31-36) show the percentage of each vision condition among cases by daily VDT use. Four observations may be made from this table and accompanying graphs:

1. The most frequently reported symptom among all categories of VDT use was eyestrain or sore eyes (overall prevalence among cases was 0.66 or 66% of the 276 workers).
2. Eyestrain or sore eyes increased in frequency with hours of VDT use.
3. Redness of eyes was reported more frequently among workers who used VDTs seven or more hours per day than workers not using VDTs at all, or compared to workers using VDTs fewer hours per day.
4. All other symptoms (blurred vision, tearing or itching eyes, and burning or irritated eyes) were reported at the same approximate prevalence by cases in each category of VDT use.

Also, vision conditions were reported not to result in many lost work days for clerical workers. Only 0.01 of the 276 workers attributed lost time to these visual conditions.

C. VISION CONDITIONS: DISCUSSION

The presented findings suggest that clerical workers who use VDTs four or more hours each day are at increased risk of developing adverse conditions related to vision. The magnitude of increased risk seems to depend on the daily duration of VDT use and not on the industry where work is done.

A relation between VDT use and adverse vision or eye conditions has been documented consistently in the research literature (Bergqvist (1984), Frank (1985), Knave (1983), Laubli (1983), Rey (1983), Schleifer (1985), and Smith M J (1981, 1983)). Some of the published studies have been criticized because of methodological problems. In 1983, the National Research Council wrote a report Video Displays, Work and Vision that commented on the limited usefulness of inadequately controlled studies. However, the NRC agreed that symptoms of eye discomfort and difficulty with vision reported by many clerical workers who use VDTs appear to be similar to symptoms reported by people performing other near-vision tasks.

There are many aspects of VDT work that could be responsible for increased adverse visual and eye conditions. These aspects may be categorized as characteristics of the visual display, of the workstation, or of the viewing task.

The display on most VDT's consists of light numbers and letters on a dark grey or green screen resulting from an electron beam repeatedly hitting light-emitting phosphorous. This positive

polarity, or light on dark display, is considered more visually stressful than dark print on a white page. Radl, 1983 showed that light alphanumeric display showed poorer readability and lessened visual comfort. VDT manufacturers have conducted extensive research on the quality of the display. Improvements suggested have included increasing the number of dots in the matrix writing of characters from 5 X 7 to 7 X 9 and from 7 X 9 to 9 X 11 and increasing the number of raster lines so that spaces between dots or lines are not visible (NRC, 1983). Refresh rates have been increased so that fluctuations in the intensity of the brightness of displays (flicker) will not be observable (Bergqvist, 1984). Tests may be done to detect jitter, variation over time in the position of display characters, which could be tiring for the operator (Bergqvist, 1984). The sharpness of the characters, or absence of blur, and choice of a clear font or character style can improve the readability of a VDT display. This research has been stimulated by findings such as those reported by Stammerjohn in 1981. In his study, operators reported several VDT characteristics as bothersome: character brightness (70%), readability (69%), flicker (68%) and screen brightness (62%). Stewart (1980) evaluated ten models of VDTs for image quality. Distracting instability was a problem on six of ten models; half the models had problems with luminance and resolution of the characters; and the shape of the characters was not acceptable in four models. Only three of the ten terminals evaluated conformed to all the

criteria and had acceptable image qualities.

Many of the adverse visual conditions seem to be traced to the placement and use of the VDT within the workplace. If computers are placed on file cabinets and desks designed for other use, problems could ensue. Lighting appropriate for paperwork could cause specular and diffuse reflections on the screen making viewing more difficult (NRC, 1983). Specular reflections are the reflected sharp images of objects that interfere with the display. To read the display, it is necessary to look through a reflected image (e.g., of operator's light colored shirt, adjacent window or light fixture). Diffuse reflections are the lighter areas of supposed dark background that reduce contrast. In other words, there is less difference between the bright display and background. Glare, that is light reflecting directly into the operator's eyes from shiny VDT surfaces, can be one of the most serious problems. (Cakir, 1980; NRC, 1983; Bergqvist, 1984; and Smith, 1982).

The third aspect of VDT work that may account for adverse conditions related to vision has to do with the visual requirements of the VDT task. A demanding aspect of VDT work is the prolonged convergence and near-vision focusing required of VDT operators (NRC, 1983; Bergqvist, 1984;and Krueger, 1980). The muscles of the eye must remain contracted to accommodate viewing at a distance of 12-20 inches. Some studies have shown that VDT operators experience difficulties focusing their eyes after VDT use all day. Changes in

visual acuity, slowed reaction time, and increased error rates have also been noted. These symptoms may be indicators of temporary visual fatigue. The long-term implications of such daily adverse changes are unknown. (Tuthill, 1985; Stellman, 1983; Laubli, 1981; and Ostberg, 1983).

With sustained accommodation and attention, operators often have a decreased blink rate. Low humidity and/or poor indoor air quality could lead to irritation of the cornea and mucous membranes of the eye. (Bergqvist, 1984; Bell Labs, 1983; and Digital, 1983).

Some VDT tasks require alternate viewing of screen, keyboard, and printed paper. Changes of viewing direction 15-75 times a minute have been observed. It is possible that the requirements of the job uncover deficits of vision that existed previously but which went undetected until the visual demands of VDT work were undertaken. Many people report needing glasses or new prescriptions after changing to a VDT intensive job. This change may also be influenced by the viewing distance, which is often intermediate between near and far vision corrections for which glasses usually are prescribed.

The finding of increased vision cases with increased hours of VDT work is especially striking given the variety of manufacturers of VDTs, type of VDT work and workstations observed. As described above, many variables can affect how visually stressful VDTs can be. The presented study includes questionnaires from word processors, customer service representatives, data entry clerks and "keypunchers"

and represent work within private industry and State employment. The VDT terminals ranged from old GCS VDTs with the keyboard and CRT as part of a single unit to the most modern flexible set-ups with glare shields and filters. Despite these variations, hours of VDT use per day were associated with vision symptoms.

In light of the presented findings the NIOSH recommendations seem appropriate and may prevent adverse health conditions. They recommend:

1. A 15-minute work-rest break should be taken after two hours of continuous VDT work for operators under moderate visual demands and/or moderate work load.
2. A 15-minute work-rest break should be taken after one hour of continuous VDT work for operators under high visual demands, high workload and/or those engaged in repetitive work tasks.

The rationale for these recommendations is based on studies documenting increased visual, musculoskeletal problems and psychological distress among VDT operators. (Murray, 1981). The work-rest break schedule NIOSH recommended is designed to minimize visual and musculoskeletal problems among VDT operators, and protect against potential chronic effects. Two different investigations found a break of 15 minutes after two hours of VDT work was sufficient for recovery from some visual symptoms (mycpia) but insufficient for other visual problems (asthenopia) or for muscular

problems. (Murray, 1981). The present study suggests a reduction of hours from the highest category of 7 - 8+ hours to 4 - 6 hours per day would lead to a reduction in the risk of developing adverse symptoms related to vision.

D. CONDITIONS RELATED TO MUSCULOSKELETAL SYSTEM

Table 3

Table 3A (page 46) and Graph 3A (page 47) show the number of workers, prevalence and prevalence ratios of musculoskeletal cases by daily video display terminal (VDT) use. These results are for all six industries combined. Table 3B (page 46) and Graph 3B (page 48) show the results for computer and data processing services, public utilities and the Commonwealth of Massachusetts combined. Results for banking, communication and hospitals combined are shown in Table 3C (page 46) and Graph 3C (page 49).

Data for all industries combined show that workers who used VDTs 1/2 to 3 hours per day had a slight decrease in the prevalence of musculoskeletal cases compared to those who did not use a VDT at all (0.15 compared to 0.17). Workers who used a VDT 4 to 6 hours per day reported a small increase in the prevalence of adverse musculoskeletal conditions compared to clerical workers who did not use a VDT at all (0.20 compared to 0.17). For those who used VDTs 7 or more hours per day, there was an 80% increase in the prevalence of musculoskeletal conditions compared to those who did not use a VDT at

all (0.31 compared to 0.17). The prevalence ratio is 1.8. The confidence interval (1.4 - 2.2) shows that it is unlikely that this increase reflects a chance occurrence.

The data for musculoskeletal conditions seem to depend on the type of industry studied. Table 3B (page 46) and Graph 3B (page 48) present the data for the 843 clerical workers from computer and data processing services, utilities, and the Commonwealth of Massachusetts. Table 3C (page 46) and Graph 3C (page 49) present the data for the 604 clerical workers from banks, communications, and hospitals. The prevalences and prevalence ratios of musculoskeletal cases differed somewhat depending upon the type of industry studied.

In Table 3B (page 46) and Graph 3B (page 48), clerical workers in the zero use, 1/2 to 3 hours of VDT use and 4 to 6 hours of VDT use groups have similar values for the prevalence of musculoskeletal conditions. In contrast, clerical workers using VDTs 7 or more hours per day had 2.2 times the prevalence of cases exhibited by clerical workers who did not use a VDT at all. This difference may be expressed as a 120% increase in the proportion of workers reporting musculoskeletal aches and pains "almost always" or missing work because of these conditions.

Table 3C (page 46) and Graph 3C (page 49) show the prevalence and prevalence ratios of musculoskeletal cases in banking, communications and hospitals. The prevalence of musculoskeletal cases is lowest among those who used VDTs 1/2 to 3 hours per day (0.14, or 14% of the 234 office workers queried). Those who did not

use a VDT at all and those who used a VDT 4 to 6 hours per day had prevalences of musculoskeletal cases of 0.20 and 0.23 respectively. Workers who used VDTs 7 or more hours per day had the highest prevalence, 0.27, a 30% increase over those not using a VDT at all. This difference in the magnitude of the prevalence ratio between high VDT use by clerical workers in this set of industries compared to those in subset B (1.3 compared to 2.2) was largely attributable to the higher prevalence of musculoskeletal conditions in the subjects who did not use VDTs among workers in banking, communications, and hospitals compared to workers in computer and data processing services, public utilities, and the Commonwealth of Massachusetts. In other words, non-VDT clerical workers in banking, communications, and hospitals had a 33% higher prevalence of musculoskeletal cases than their counterparts in computer and data processing services, public utilities, and the Commownwealth of Massachusetts.

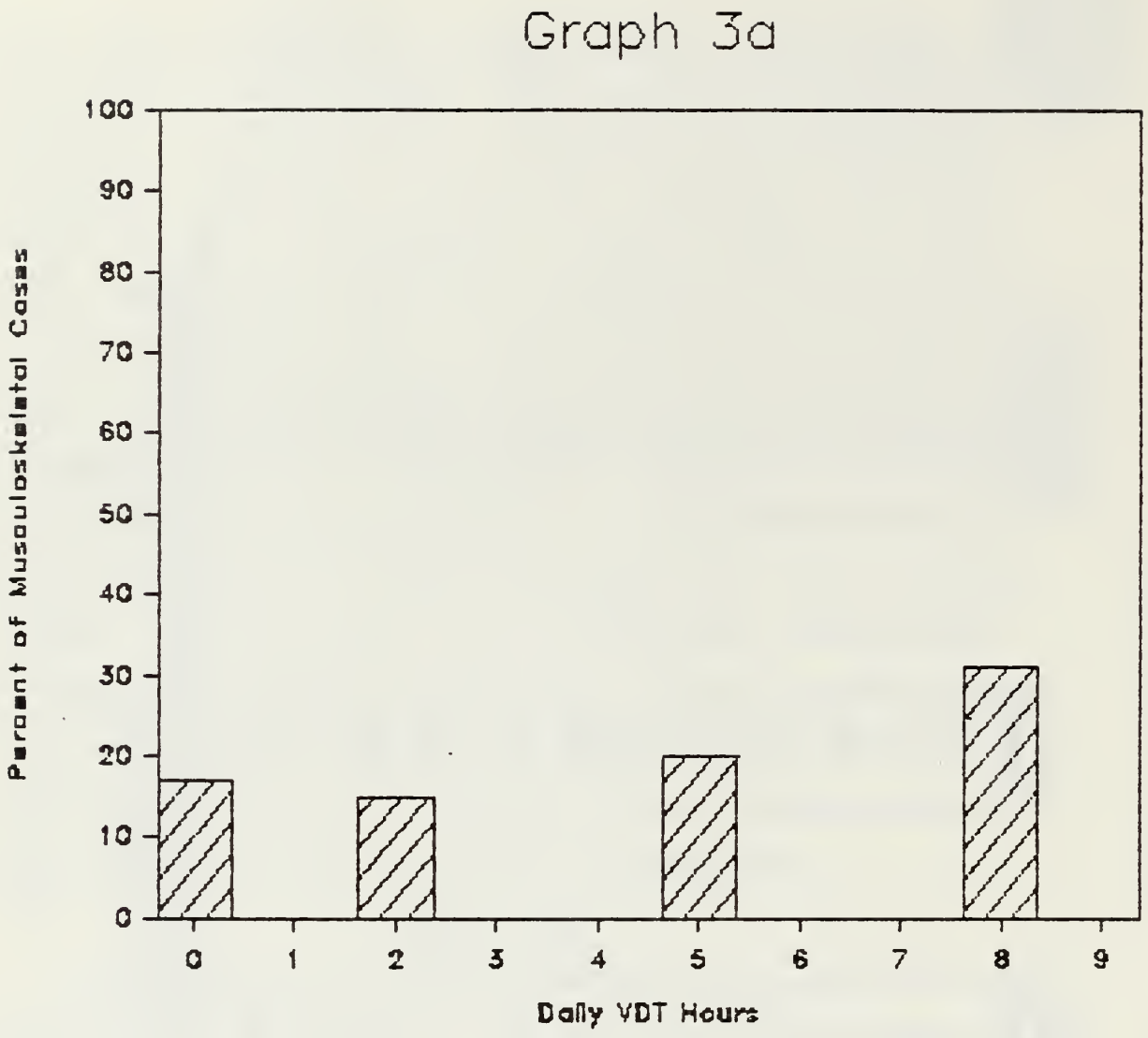
Tables 4 and 5

Table 4 (page 50) and Graphs 4A through 4H (page 51-58) show the prevalence of musculoskeletal conditions among the 191 workers in computer and data processing services, public utilities, and the Commonwealth of Massachusetts who met the study definition of a musculoskeletal case, presented according to category of daily VDT use. Table 5 (page 59) and Graphs 5A through 5H (page 60-67) show the corresponding data for the 117 musculoskeletal cases in banking, communications, and hospitals. In other words, these two tables

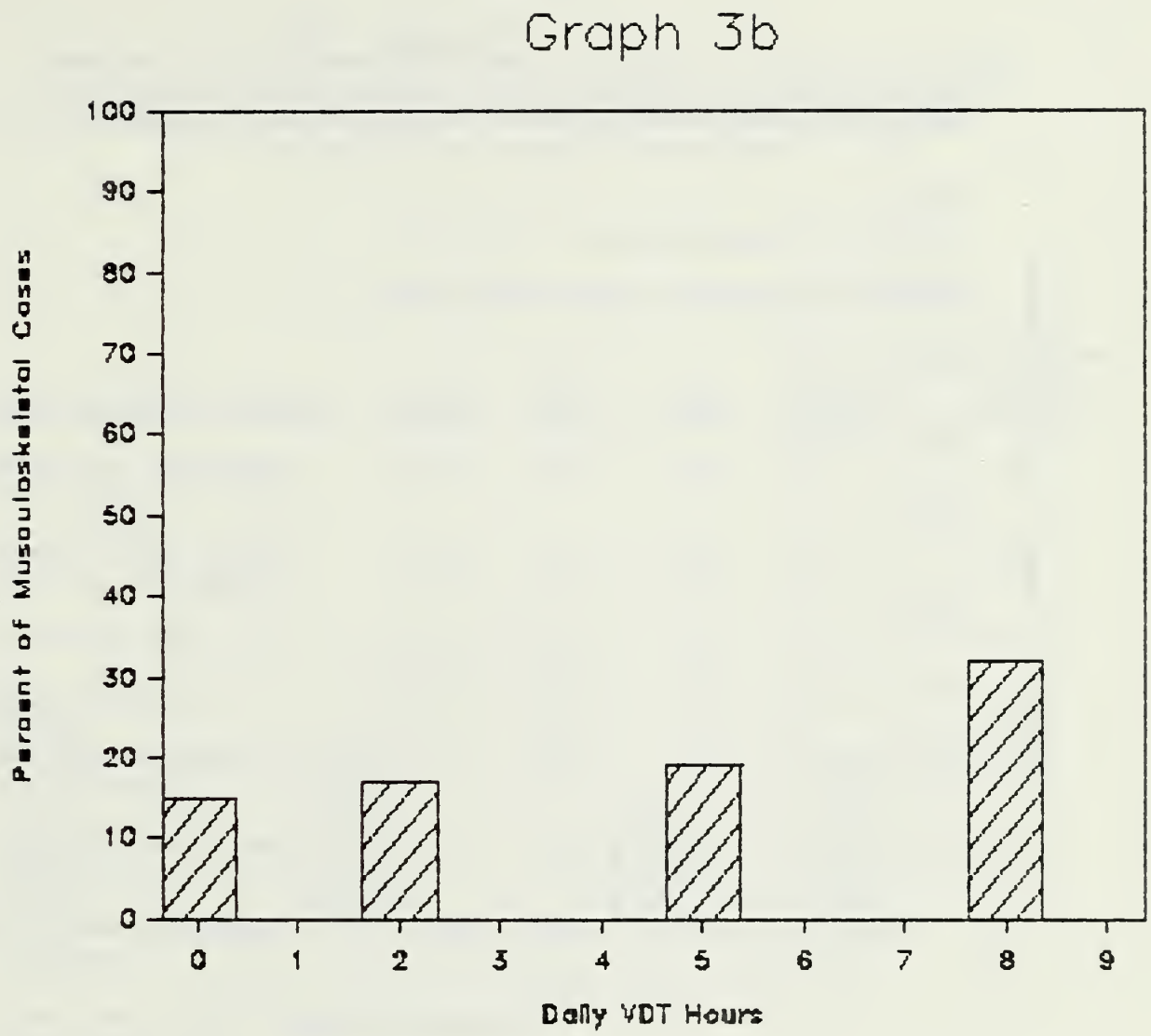
Number of Workers, Prevalence and Prevalence Ratios of Musculoskeletal Cases Among Office Workers by Daily Video Display Terminal Use and Industry

	Industry	Daily Video Display Terminal Use (Hours)	Number of Workers	Prevalence of Musculoskeletal Cases	Prevalence of of Musculoskeletal (90% Confidence Interval)
A.	All	0	366	0.17	1.0 -
		1/2 - 3	417	0.15	0.9 (0.7 - 1.1)
		4 - 6	250	0.20	1.2 (0.9 - 1.5)
		7 or more	414	0.31	1.8 (1.4 - 2.2)
B.	Computer and Data Processing Services, Public Utilities, and Massachusetts State Depts.	0	188	0.15	1.0 -
		1/2 - 3	183	0.17	1.1 (0.8 - 1.7)
		4 - 6	151	0.19	1.2 (0.8 - 1.9)
		7 or more	321	0.32	2.2 (1.6 - 2.9)
C.	Banking, Communications,* and Hospitals	0	178	0.20	1.0 -
		1/2 - 3	234	0.14	0.7 (0.5 - 1.0)
		4 - 6	99	0.23	1.1 (0.8 - 1.7)
		7 or more	93	0.27	1.3 (0.9 - 1.9)

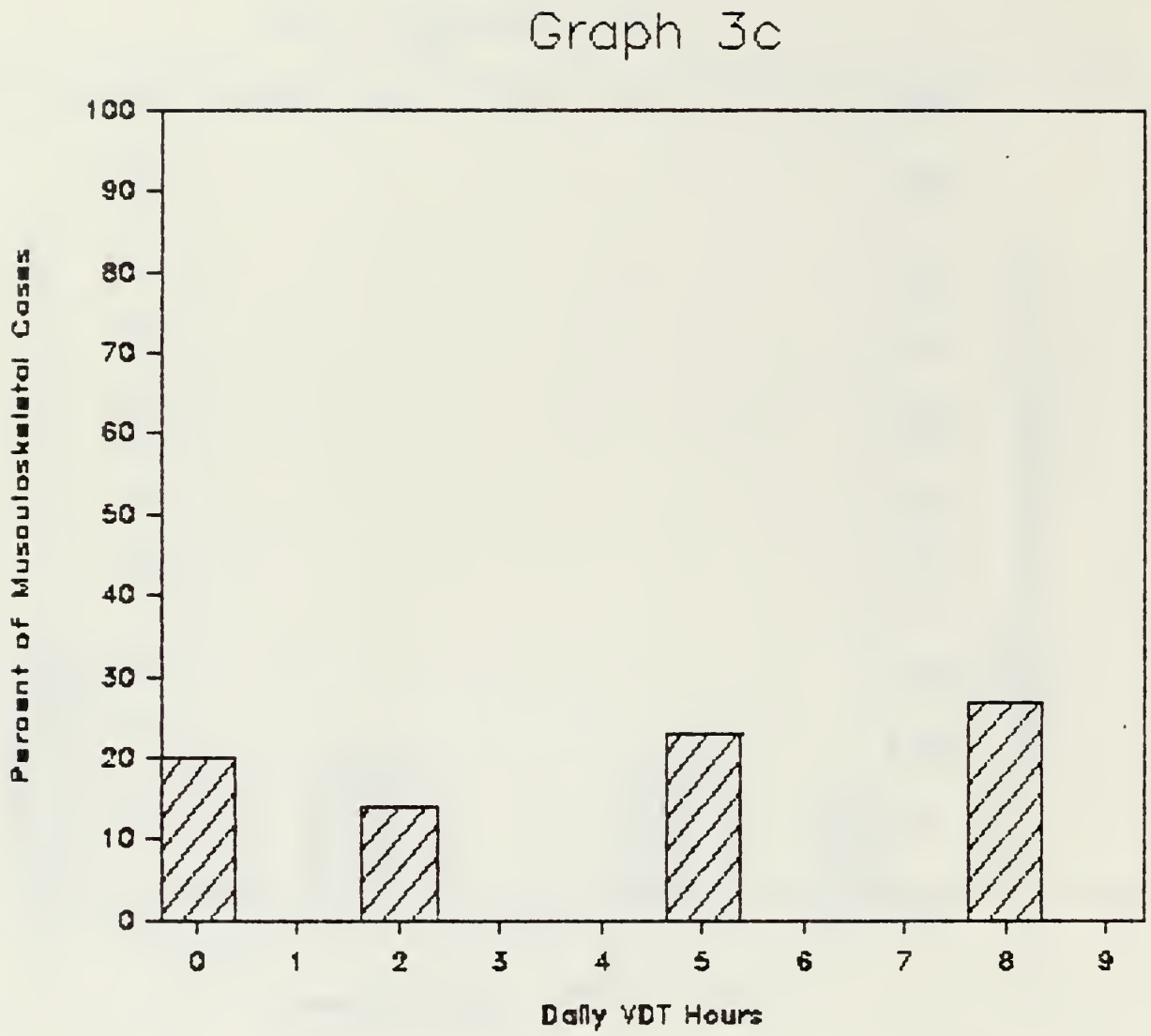
* Although the participation rate for industries in communications was 80 percent, the largest employer in this industry group, representing approximately 60 percent of all Massachusetts employees in communications, did not participate in the study.



Graph 3a: Percent of musculoskeletal cases among office workers in all six industries by daily video display terminal use



Graph 3b: Percent of musculoskeletal cases among office workers in Computer Services, Public Utilities, and the Commonwealth by daily video display terminal use

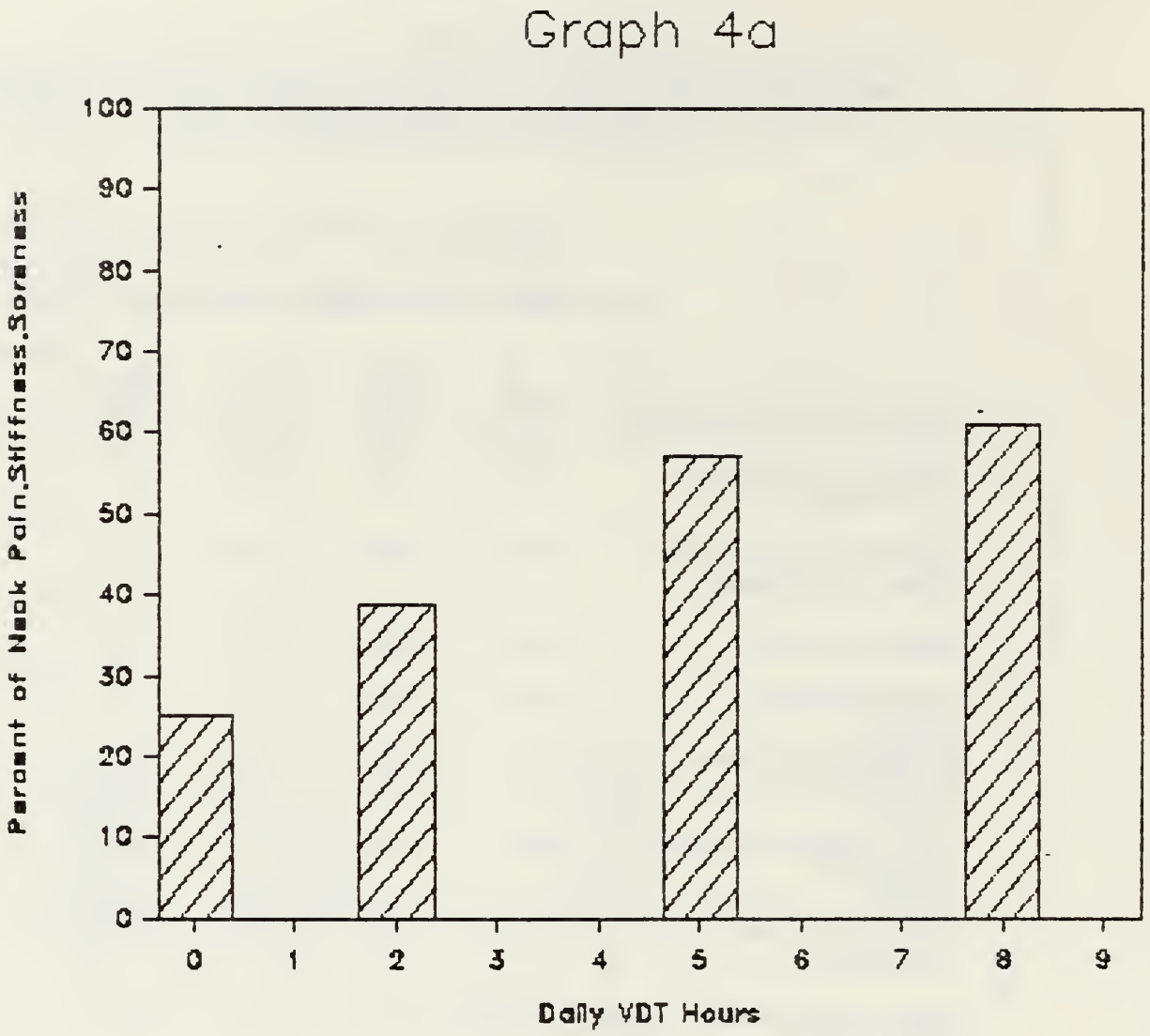


Graph 3c: Percent of musculoskeletal cases among office workers in Banking, Communications, and Hospitals by daily video display terminal use

TABLE 4

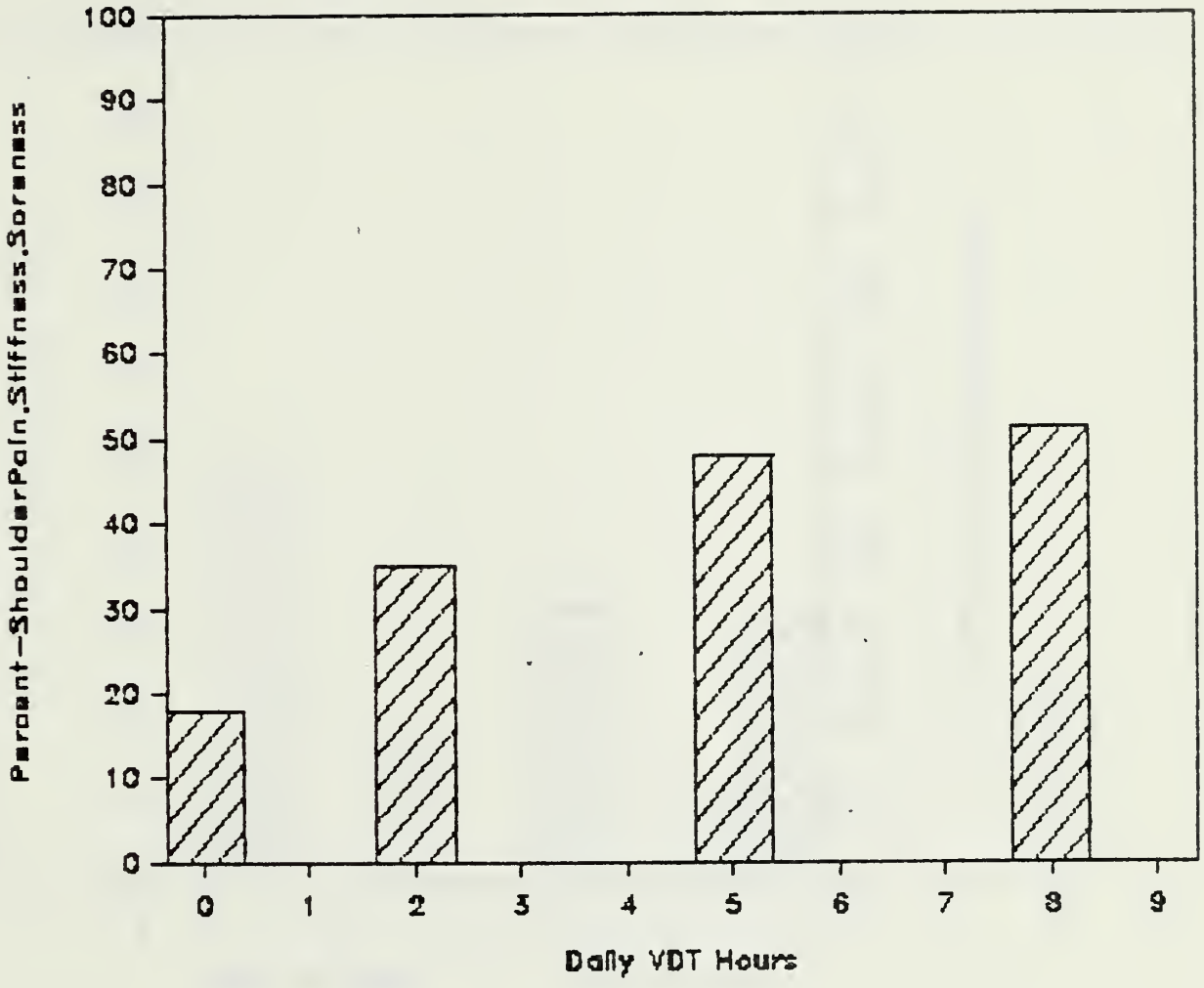
Prevalence of Musculoskeletal Conditions Reported as Occurring Almost Always Among Musculoskeletal Cases in Computer and Data Processing Services, Public Utilities, or Massachusetts State Departments by Daily Video Display Terminal Use

	Prevalence of Musculoskeletal Condition				
	Daily Video Display Terminal Use (Hours)				
Musculoskeletal Condition	0 (N=28)	1/2-3 (N=31)	4-6 (N=28)	7 or more (N=104)	All Categories of use (N=191)
Neck Pain, Stiffness, or Soreness	0.25	0.39	0.57	0.61	0.51
Shoulder Pain, Stiffness, or Soreness	0.18	0.35	0.48	0.51	0.43
Lower Back Pain	0.32	0.33	0.50	0.46	0.43
Upper Back Pain	0.14	0.17	0.11	0.24	0.19
Arm Pain, Stiffness, or Soreness	0.21	0.16	0.26	0.17	0.19
Pain in Hands, Fingers, or Wrists	0.29	0.19	0.14	0.14	0.17
Numbness or Tingling in Hands	0.07	0.10	0.07	0.09	0.08
Missed Work Because of Musculoskeletal Condition	0	0	0	0.01	0.01

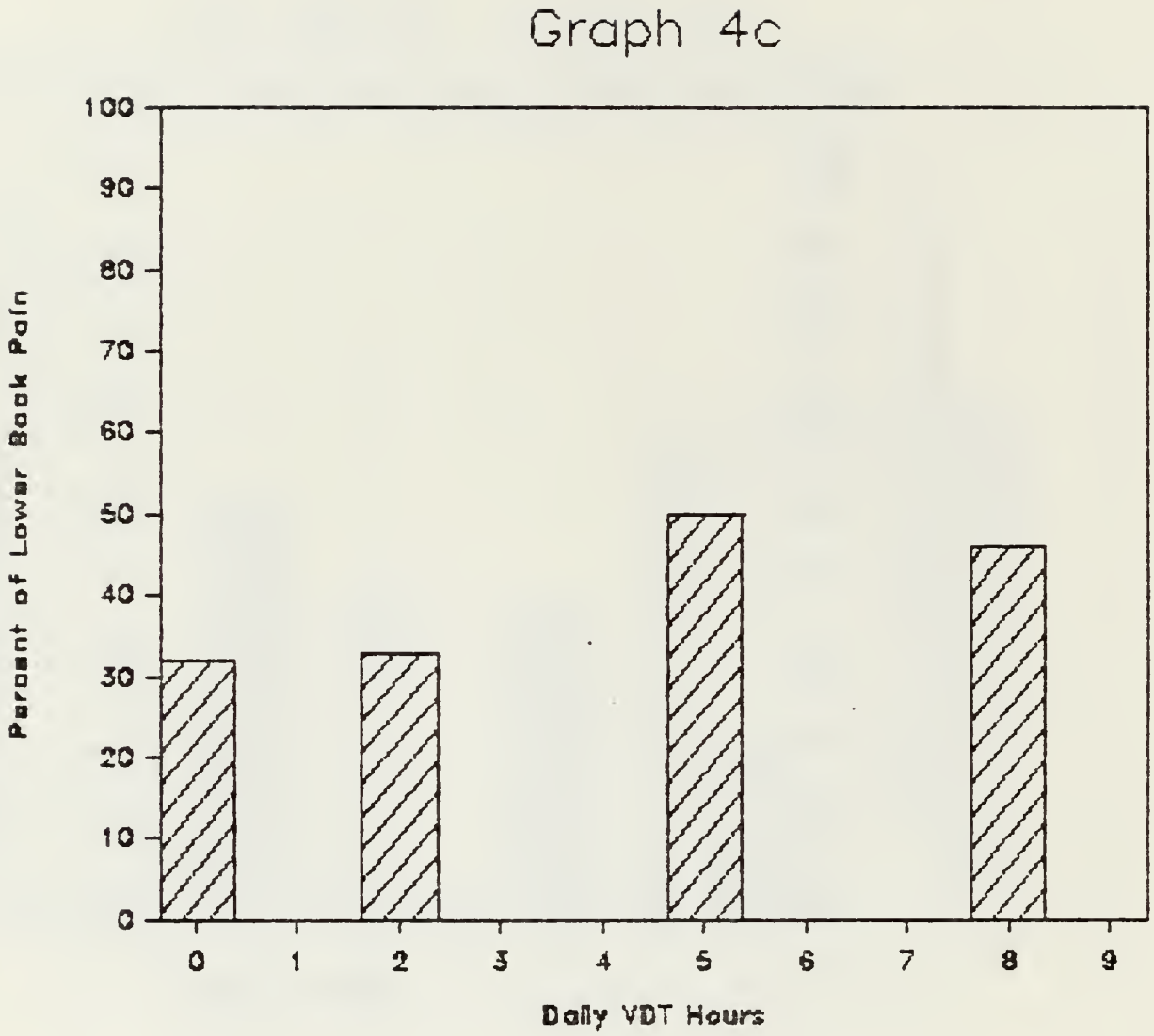


Graph 4a: Percent of musculoskeletal condition, neck pain, stiffness, or soreness, reported as occurring almost always or causing missed work among musculoskeletal case in Computer Services, Public Utilities, and the Commonwealth by daily video display terminal use

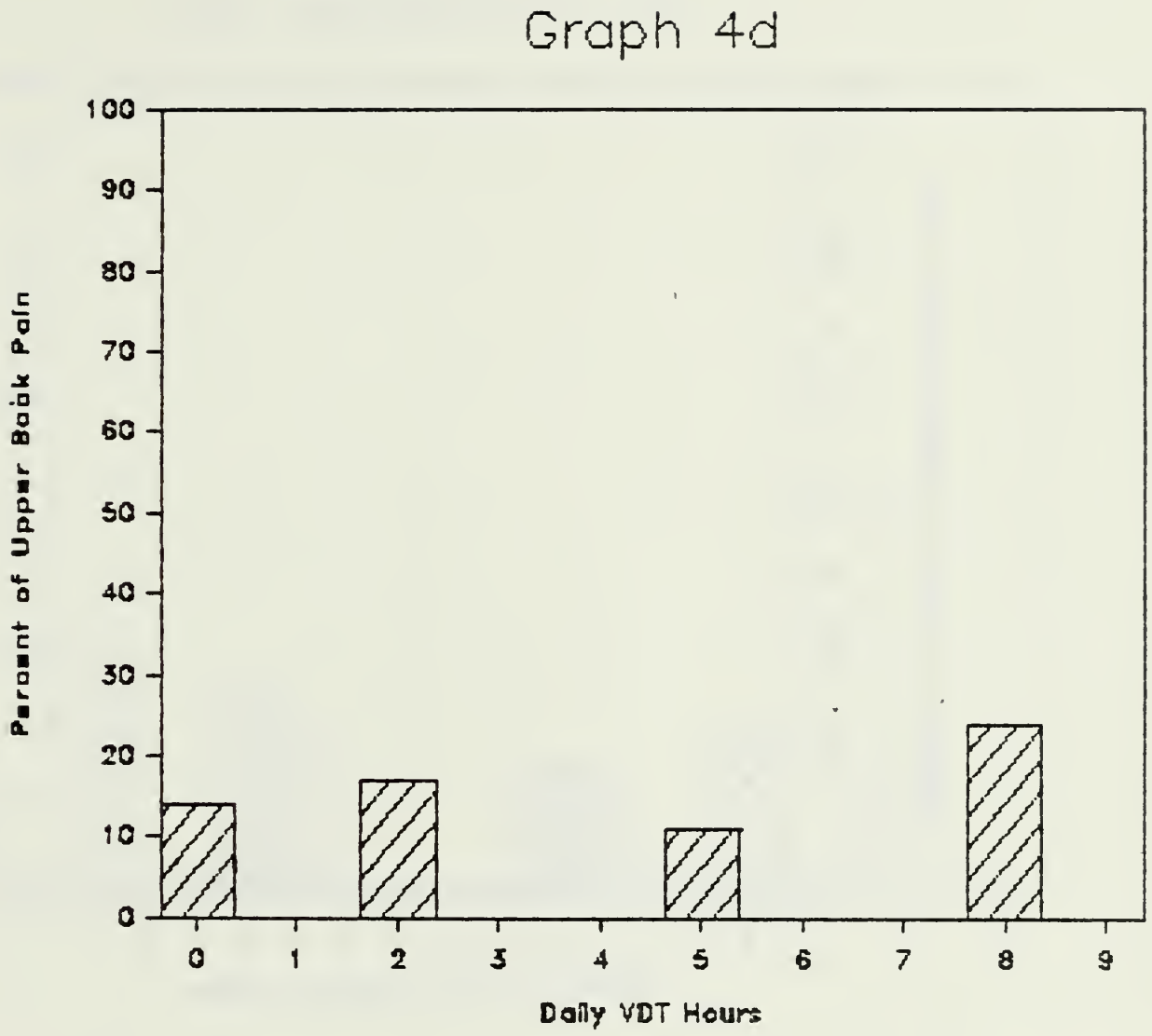
Graph 4b



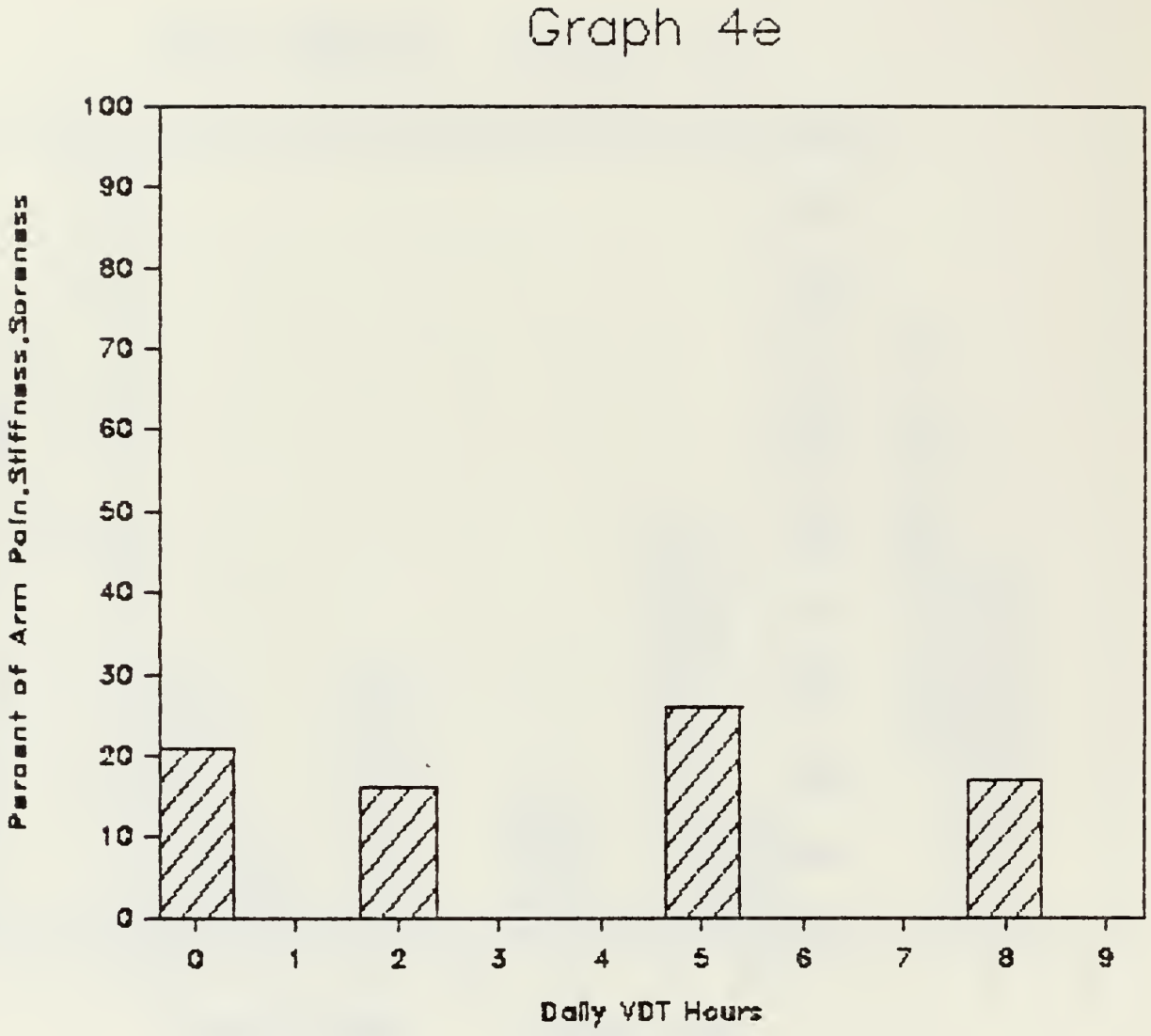
Graph 4b: Percent of musculoskeletal condition, shoulder pain, stiffness or soreness, reported as occurring almost always or causing missed work among musculoskeletal cases in Computer Services, Public Utilities, and the Commonwealth by video display terminal use



Graph 4c: Percent of musculoskeletal condition, lower back pain, reported as occurring almost always or causing missed work among musculoskeletal cases in Computer Services, Public Utilities, and the Commonwealth by daily video display terminal use

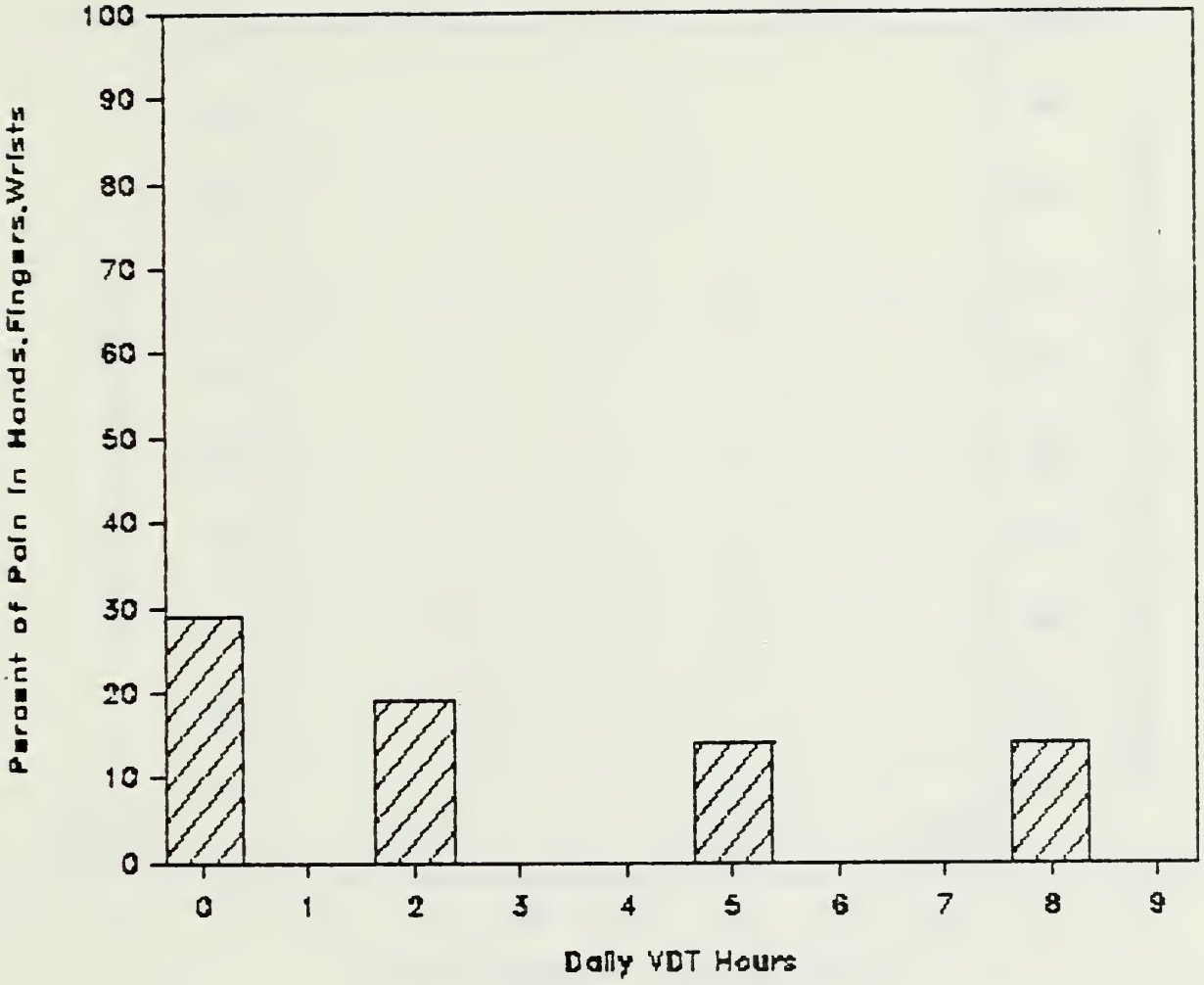


Graph 4d: Percent of musculoskeletal condition, upper back pain, reported as occurring almost always or causing missed work among musculoskeletal cases in Computers Services, Public Utilities, and the Commonwealth by daily video display terminal use

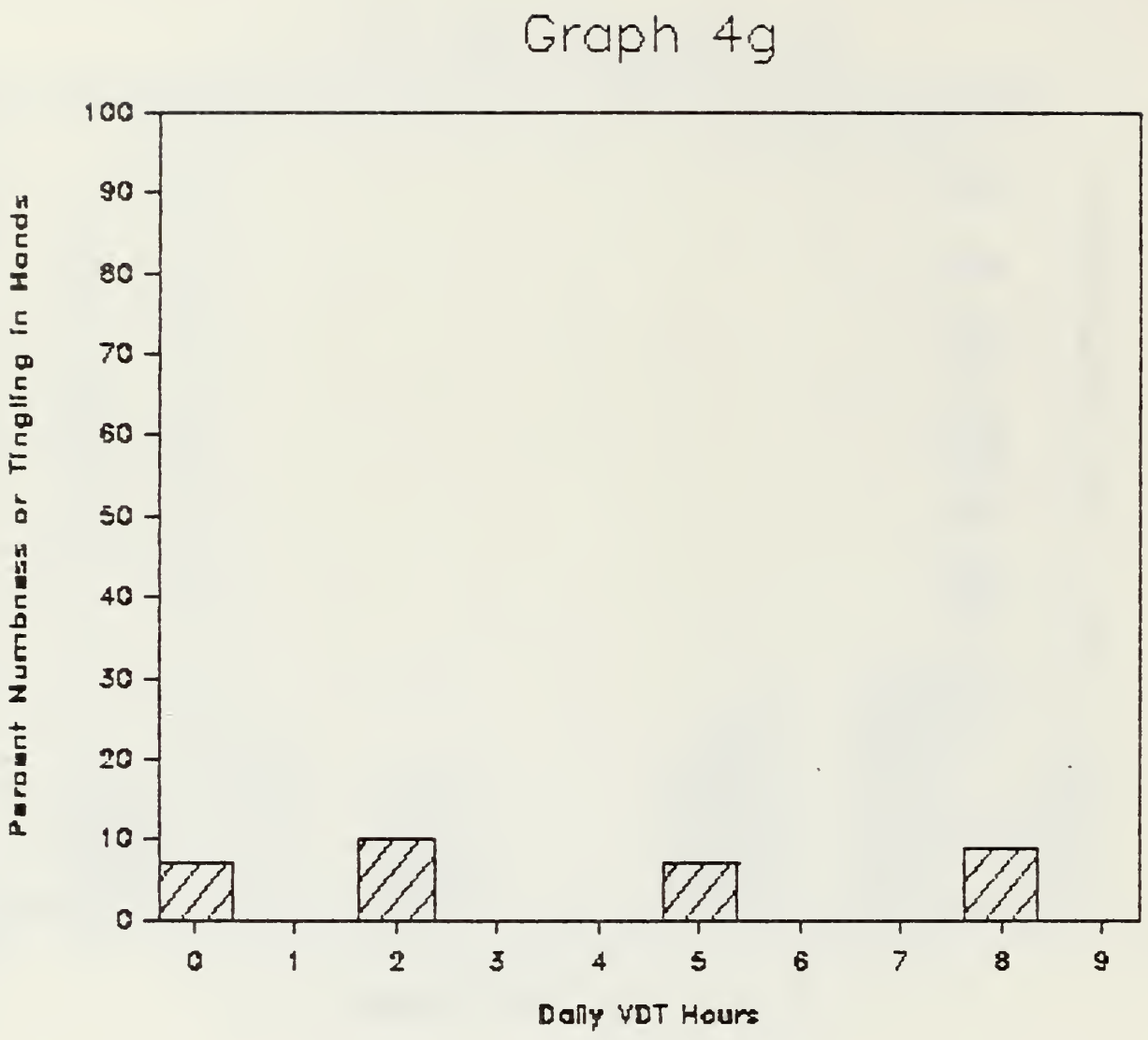


Graph 4e: Percent of musculoskeletal condition, arm pain, stiffness or soreness, reported as occurring almost always or causing missed work among musculoskeletal cases in Computer Services, Public Utilities, and the Commonwealth by daily video display terminal use

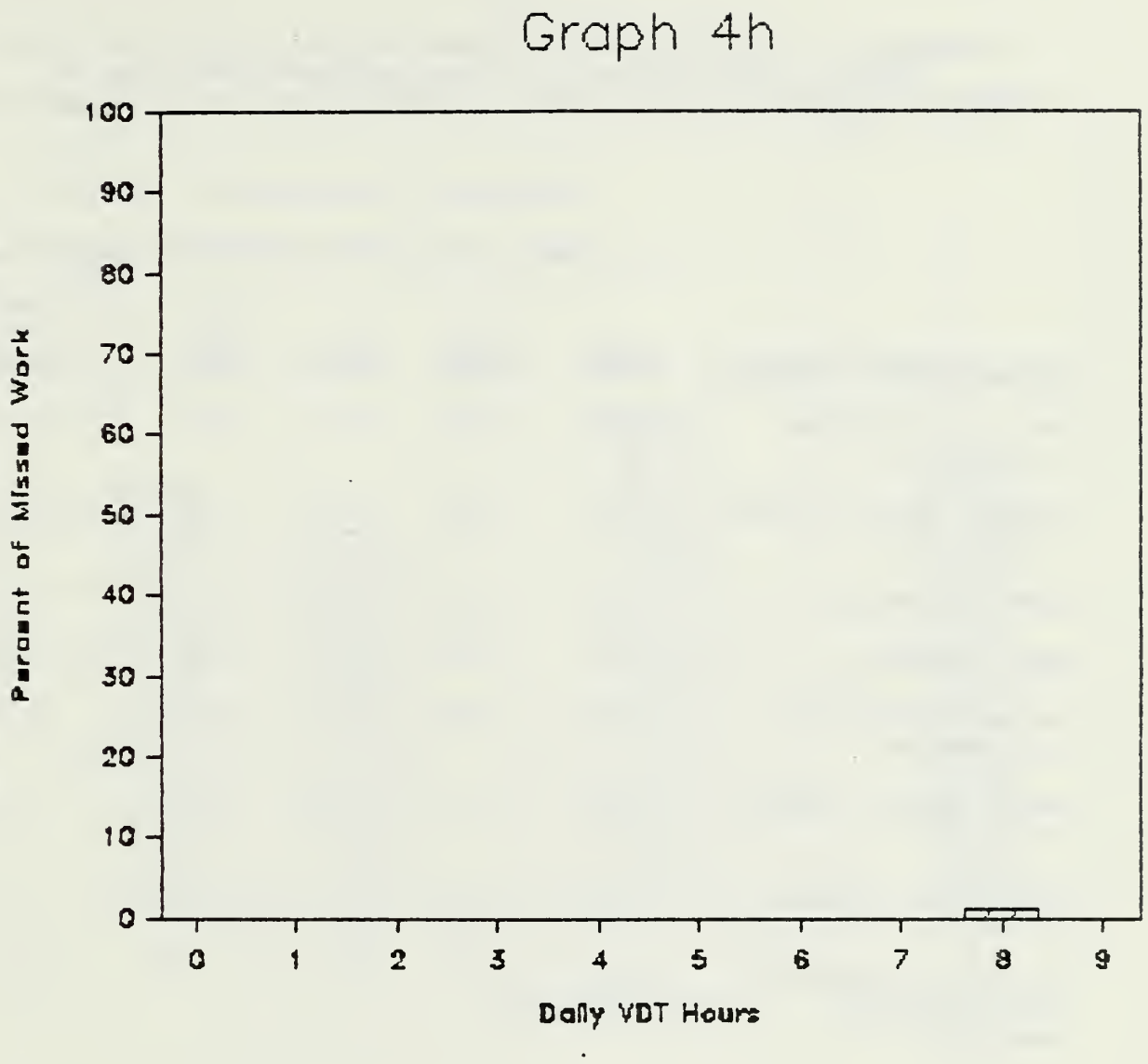
Graph 4f



Graph 4f: Percent of musculoskeletal condition, pain in hands, fingers or wrists, reported as occurring almost always or causing missed work among musculoskeletal cases in Computer Services, Public Utilities, and the Commonwealth by daily video display terminal use



Graph 4g: Percent of musculoskeletal condition, numbness or tingling in hands, reported as occurring almost always or causing missed work among musculoskeletal cases in Computer Services, Public Utilities, and the Commonwealth by daily video display terminal use



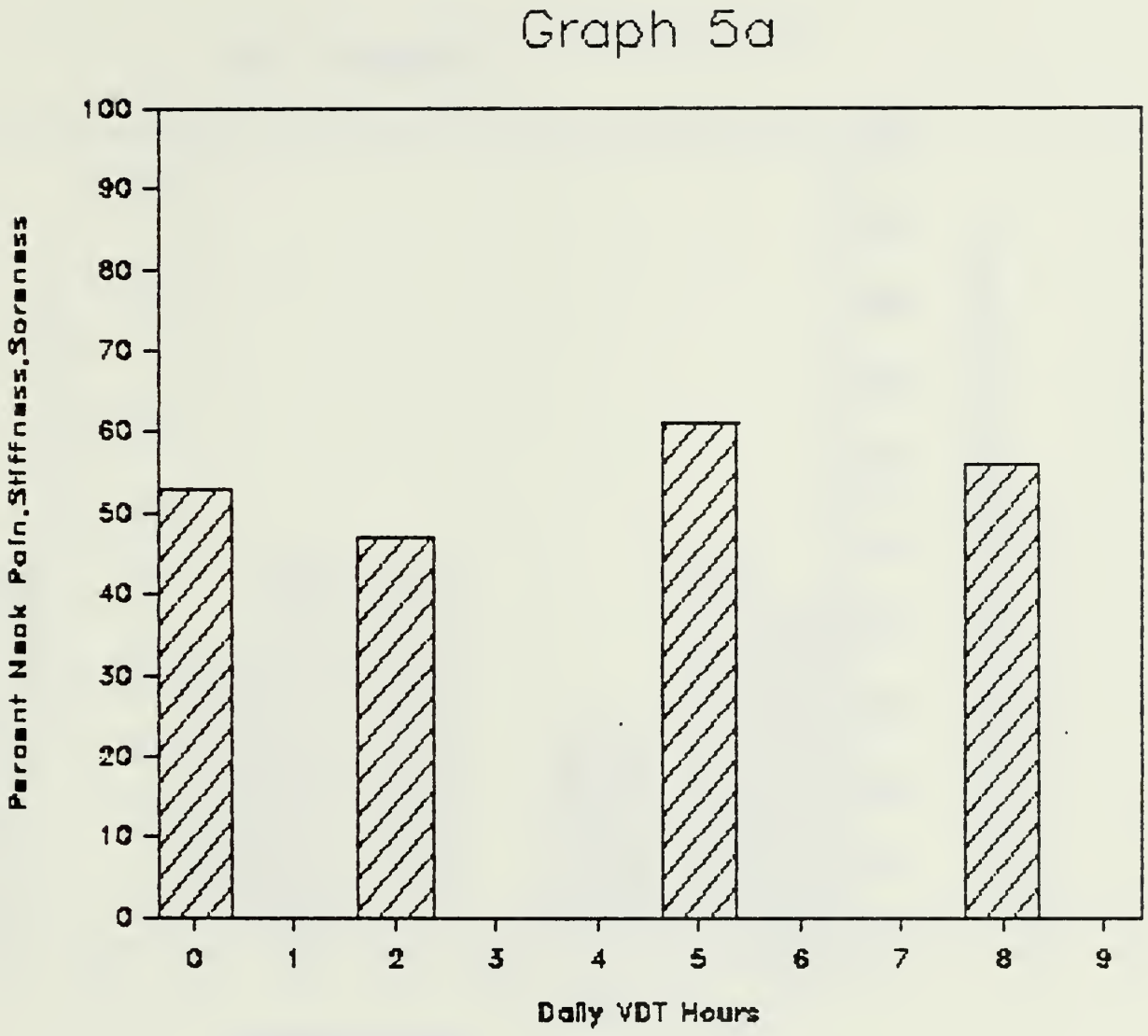
Graph 4h: Percent of condition, missed work because of musculoskeletal condition, reported among musculoskeletal cases in Computer Services, Public Utilities, and the Commonwealth by daily video display terminal use

TABLE 5

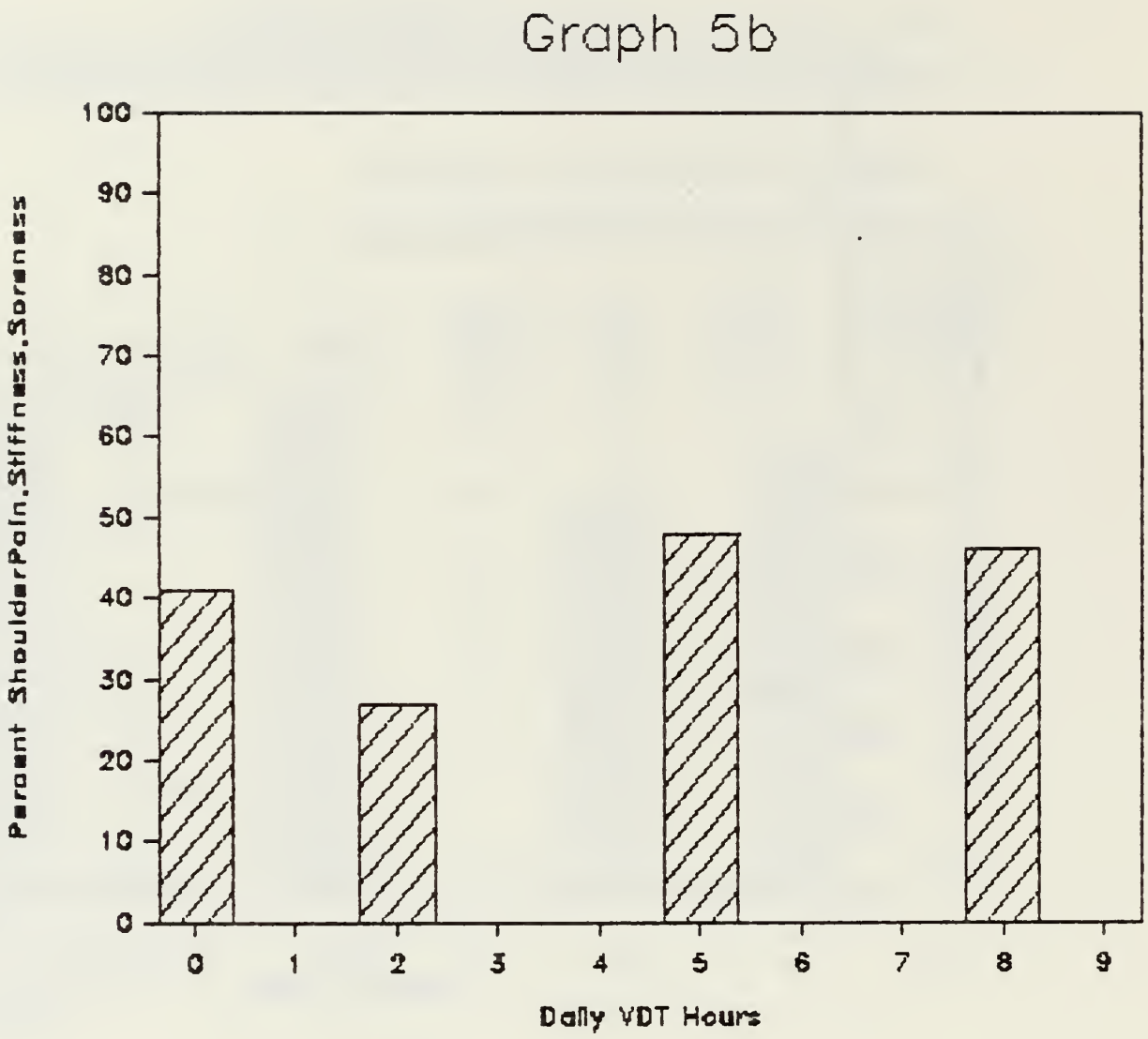
Prevalence of Musculoskeletal Conditions Reported as Occurring Almost Always or Causing Missed Work Among Musculoskeletal Cases in Banking, Communications,* or Hospitals by Daily Video Display Terminal Use

	Prevalence of Musculoskeletal Condition				
	Daily Video Display Terminal Use (Hours)				
Musculoskeletal Condition	0 (N=36)	1/2-3 (N=33)	4-6 (N=23)	7 or more (N=25)	All Categories of use (N=117)
Neck Pain, Stiffness, or Soreness	0.53	0.47	0.61	0.56	0.54
Shoulder Pain, Stiffness, or Soreness	0.41	0.27	0.48	0.46	0.39
Lower Back Pain	0.31	0.42	0.45	0.52	0.41
Upper Back Pain	0.21	0.19	0.24	0.25	0.22
Arm Pain, Stiffness, or Soreness	0.22	0.16	0.17	0.38	0.23
Pain in Hands, Fingers, or Wrists	0.20	0.13	0.13	0.36	0.20
Numbness or Tingling in Hands	0.20	0.09	0	0.16	0.12
Missed Work Because of Musculoskeletal Condition	0.06	0	0.04	0	0.03

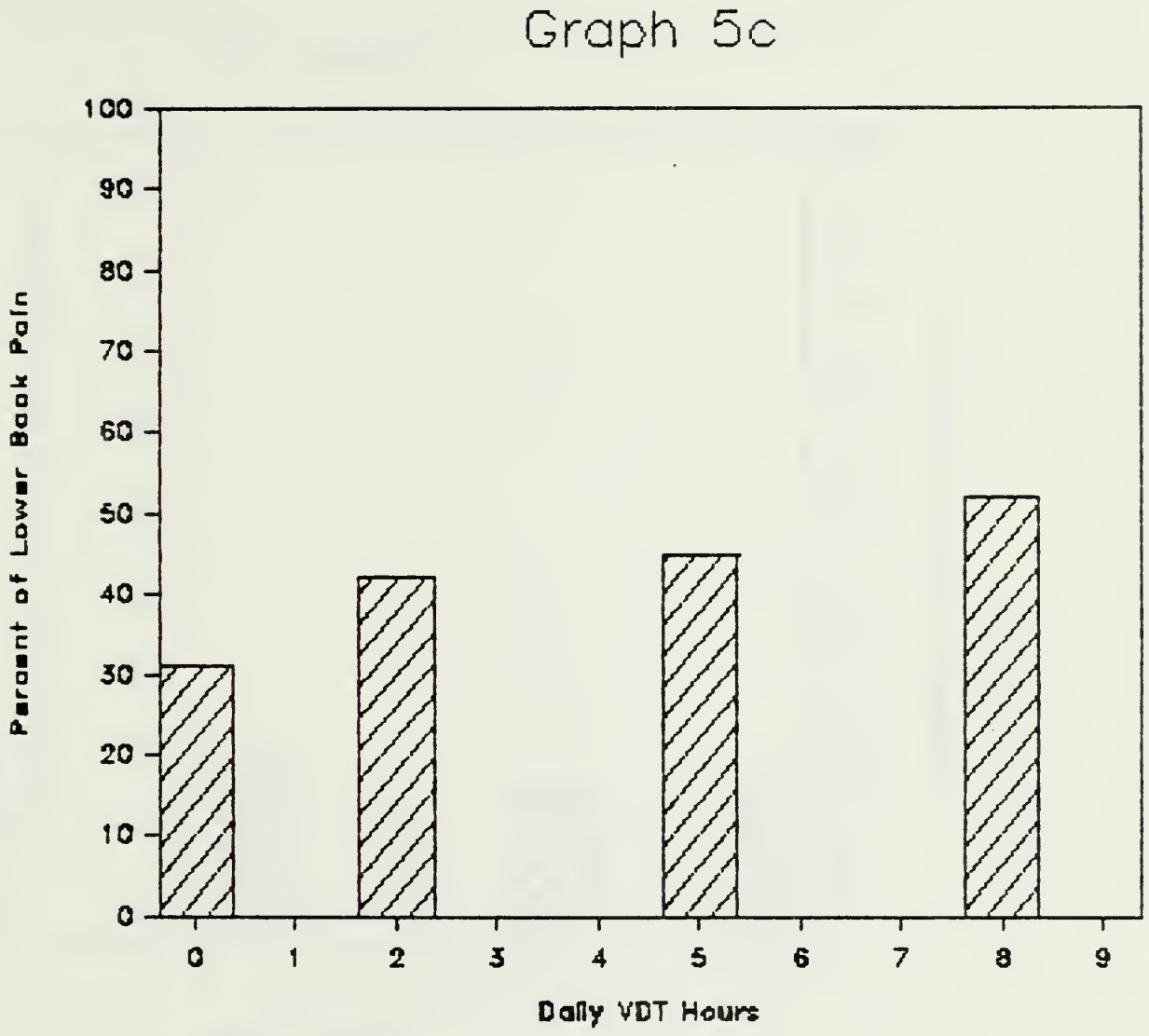
* Although the participation rate for industries in communications was 80 percent, the largest employer in this industry group, representing approximately 60 percent of all Massachusetts employees in communications, did not participate in the study.



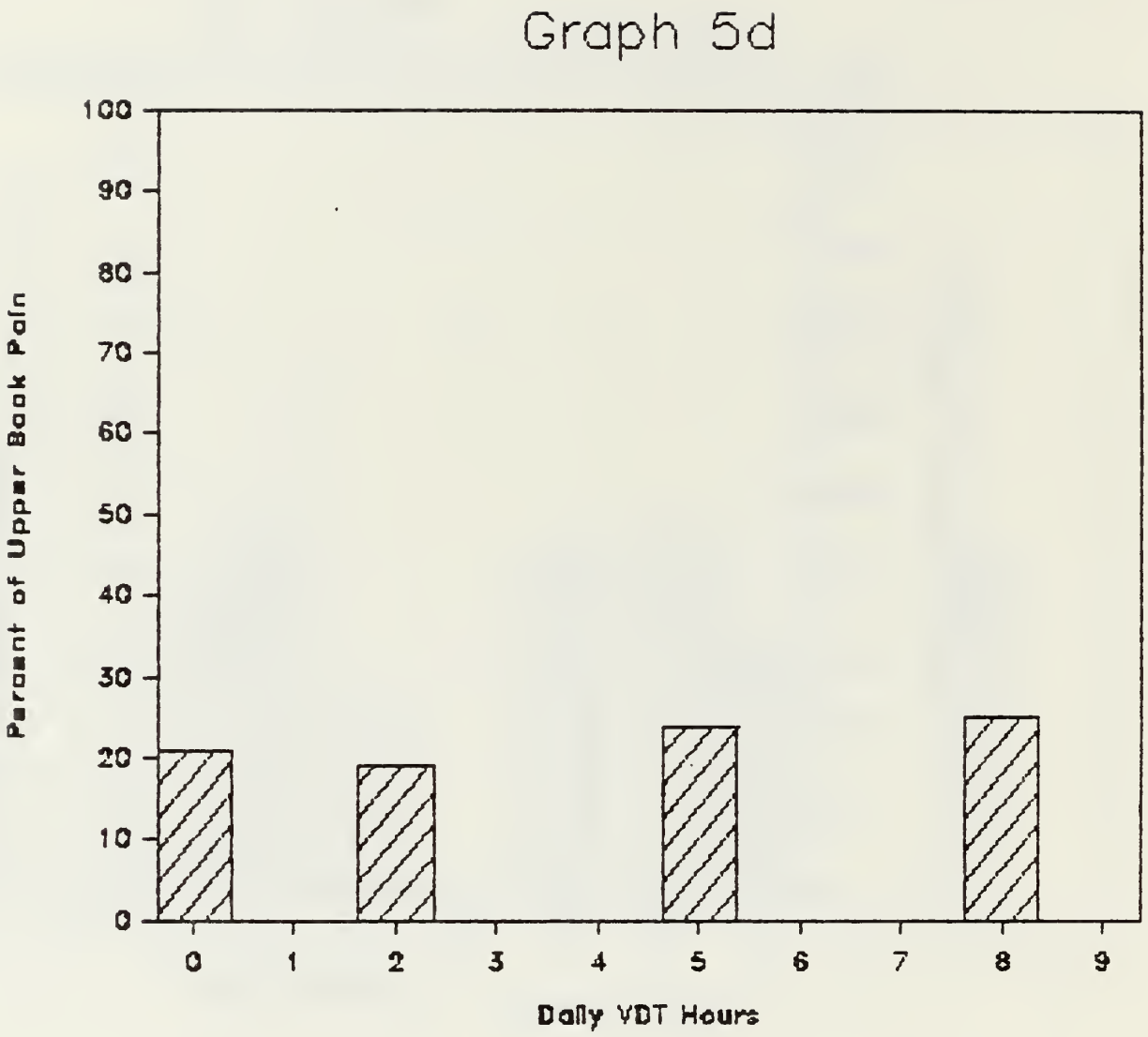
Graph 5a: Percent of musculoskeletal condition, neck pain, stiffness, or soreness, reported as occurring almost always or causing missed work among musculoskeletal cases in Banking, Communications, and Hospitals by daily video display terminal use



Graph 5b: Percent of musculoskeletal condition, shoulder pain, stiffness, or soreness, reported as occurring almost always or causing missed work among musculoskeletal cases in Banking, Communications, and Hospitals by daily video display terminal use

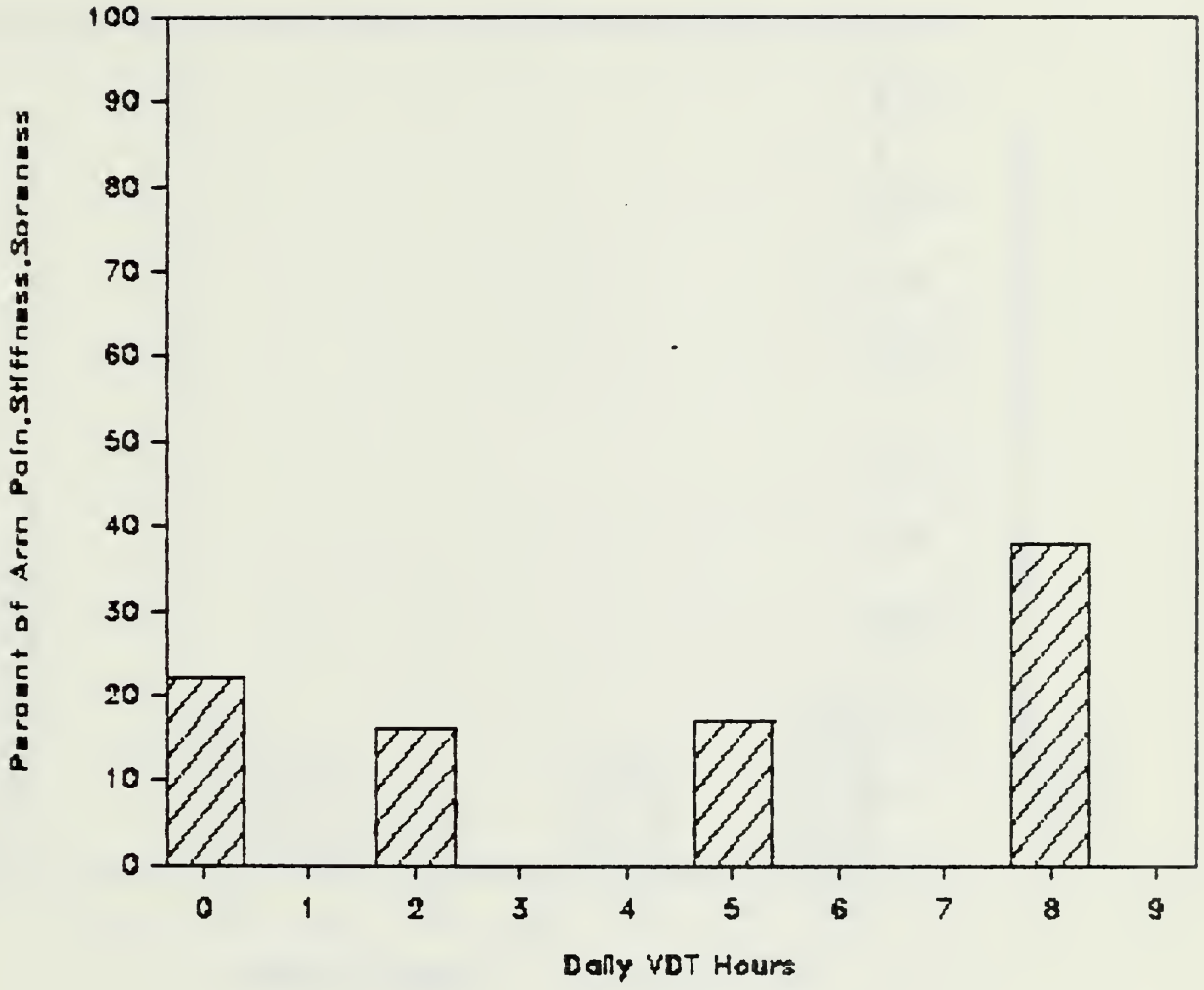


Graph 5c: Percent of musculoskeletal condition, lower back pain, reported as occurring almost always or causing missed work among musculoskeletal cases in Banking, Communications, and Hospitals by daily video display terminal use



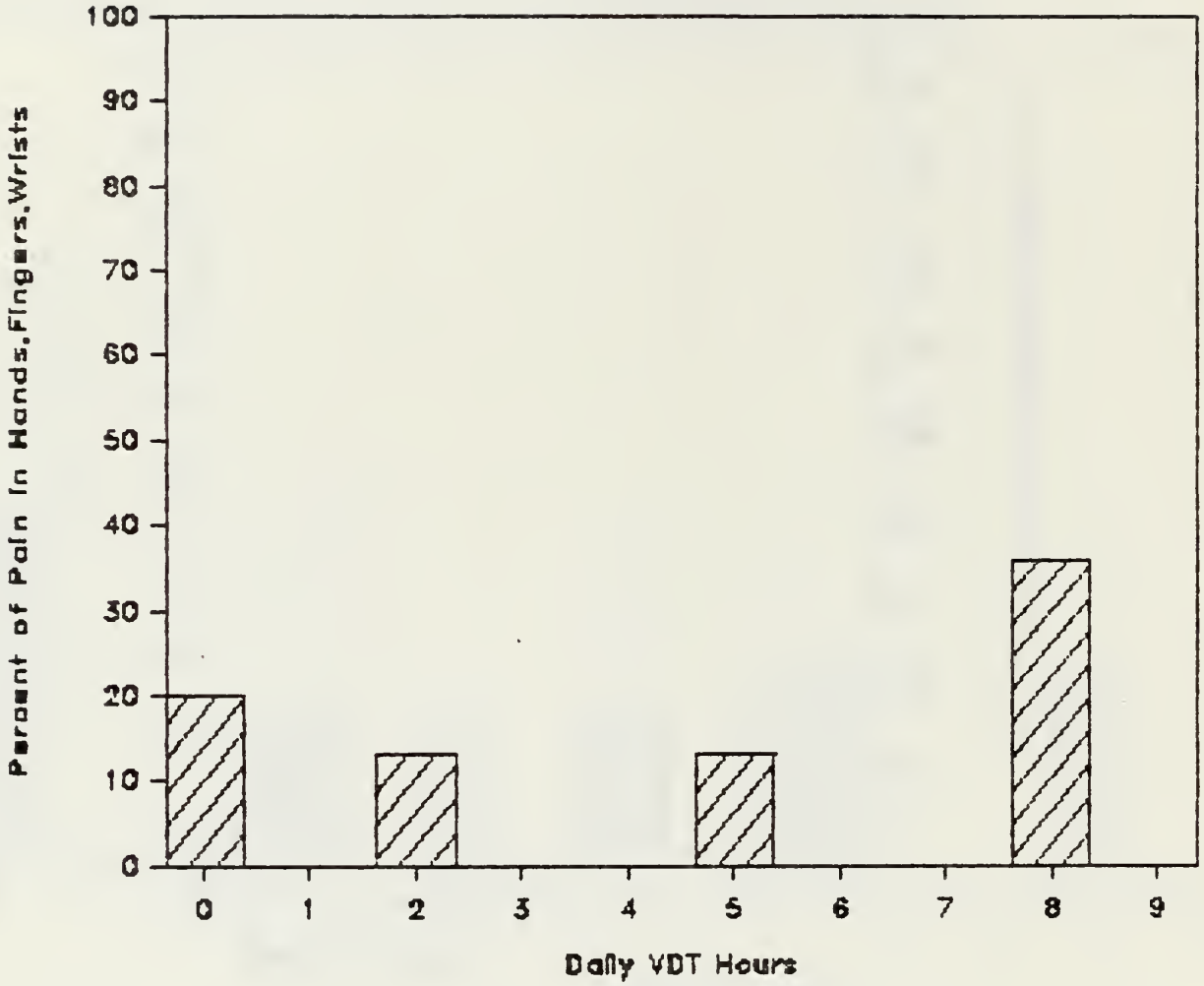
Graph 5d: Percent of musculoskeletal condition, upper back pain, reported as occurring almost always or causing missed work among musculoskeletal cases in Banking, Communications, and hospitals by daily video display terminal use

Graph 5e

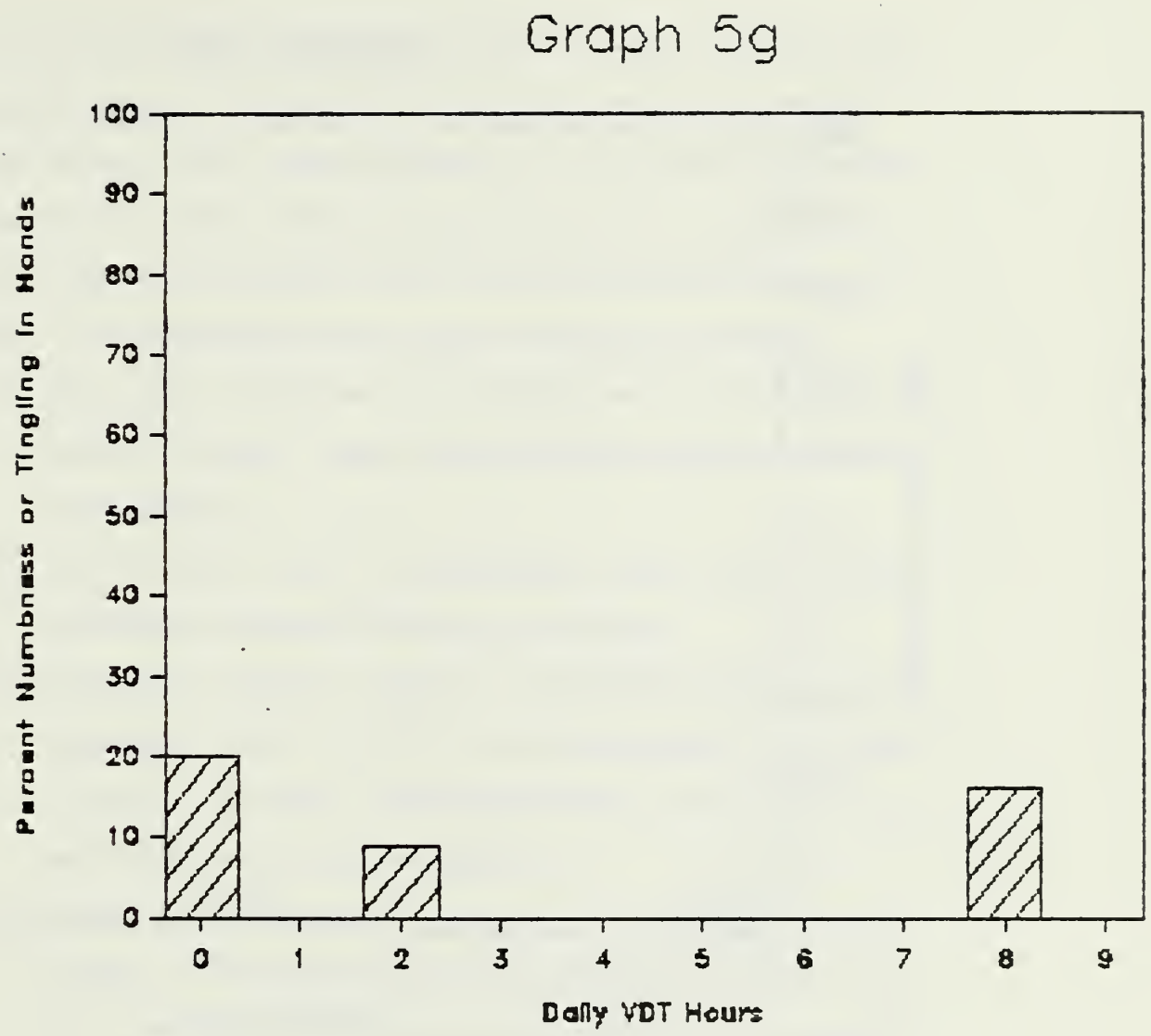


Graph 5e: Percent of musculoskeletal condition, arm pain, stiffness or soreness, reported as occurring almost always or causing missed work among musculoskeletal cases in Banking, Communications, and Hospitals by daily video display terminal use

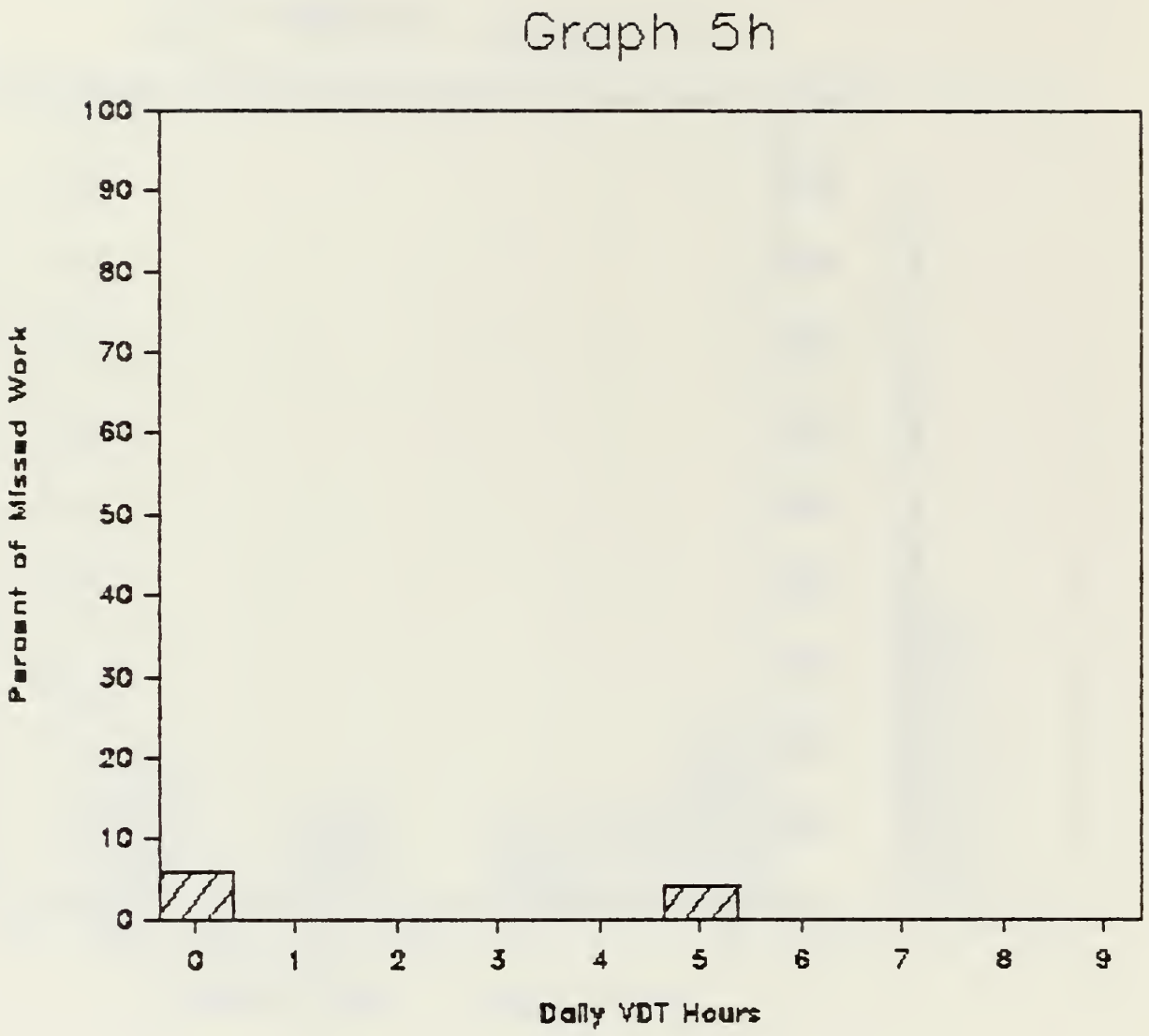
Graph 5f



Graph 5f: Percent of musculoskeletal condition, pain in hands, fingers, or wrists, reported as occurring almost always or causing missed work among musculoskeletal cases in Banking, Communications, and Hospitals by daily video display terminal use



Graph 5g: Percent of musculoskeletal condition, numbess or tingling in hands, reported as occurring almost always or causing missed work among musculoskeletal cases in Banking, Communications, and Hospitals by daily video display terminal use



Graph 5h: Percent of condition, missed work because of musculoskeletal condition, reported among musculoskeletal cases in Banking, Communications, and Hospitals by daily video display terminal use

indicate which of the musculoskeletal conditions were reported by the 191 out of 843 = 23% and 117 out of 604 = 19% of respondents who reported having such symptoms almost all the time and/or who missed work because of them. The percentages do not sum to 100% because a case is included in the table once for each musculoskeletal condition reported. Five observations may be made from these two tables:

(1) Neck pain, stiffness, or soreness was the most frequently reported symptom among musculoskeletal cases in both sets of industries.

(2) In the both sets of industries, lower back pain case prevalence increased with hours of VDT use.

(3) Neck and shoulder conditions increased in frequency with increasing hours of VDT use in one subset of industries (computer and data processing services, public utilities, and Commonwealth of Massachusetts).

(4) There was a decreased frequency of pain in the hands, fingers, or wrists among cases in computers, utilities, and the Commonwealth of Massachusetts industries. A comparable decrease was not found in banking, communications, and hospitals.

(5) All other symptoms (upper back pain, arm pain, stiffness, or soreness and numbness or tingling in hands) were reported at varying prevalences with no apparent trend with hours of VDT use. Also, musculoskeletal conditions did not

result in many lost workdays for clerical workers. Only one percent of 191 cases in computers and data processing services, public utilities, or Commonwealth of Massachusetts offices and three percent of the 117 cases in banking, communications, and hospitals attributed lost work time to musculoskeletal problems. In the latter subset of industries, the group reporting the most lost time were non-VDT clerical workers.

E. DISCUSSION: MUSCULOSKELETAL CONDITIONS

An increased prevalence of musculoskeletal discomfort was observed among clerical workers who use VDTs seven or more hours per day. The increase was apparent mainly in computer and data processing services, public utilities, and Commonwealth of Massachusetts offices. The most common sites of discomfort were the neck, shoulder, and lower back.

Working at a computer terminal frequently requires the operator to assume fixed postures for extended periods of time. Such positions could lead to musculoskeletal stress and strains and resultant aches and pains. As described by Henifin in her chapter, "Video Display Terminals", in Double Exposure (1984):

> Biomechanical strains occur when the human body is forced to conform to a machine rather than having the machine designed to fit the wide range of human shapes and sizes...A poorly designed workstation forces the operator to sit for long periods in a position where the muscles and joints are in an awkward or unnatural position.

A study conducted by Hunting and his co-workers (1980) found an increased incidence of "almost daily" musculoskeletal pains among operators at data entry terminals and conversational terminals compared to typists and traditional office workers. They also found increased visits to a physician for arm and hand impairment and medical findings of painful indurations in neck muscles in the groups characterized by high speed work. Bergqvist (1984) reviewed the findings from a NIOSH study of three office settings (Murray, 1981). Bergqvist found a greater tendency for VDT operators to report that their symptoms were "frequent or constant" more than referents.

Adjustable chairs and desks and detachable keyboards will allow some adjustment of the workstation to meet the operators needs. Ideally, such workstations will allow flexibility and a variety of comfortable positions. Swivel monitors, document stands, appropriate lighting and wrist supports all contribute to a better ergonomic workstation. The Canadian Business Equipment Manufactures Association observed, "human energies should go into the task at hand, not into finding a comfortable position. Equipment should be adjusted to people's needs, not the other way around." Prolonged hours of VDT use requires individuals to maintain static positions with little movement. Constrained posture and static loading of muscles could lead to the musculoskeletal difficulties observed in this study. For workers using VDTs seven or more hours per day, it seems likely that there are no regular activities which interrupt and

allow respite from their VDT tasks. Some respondents reported leaving their desks only twice per day. Others (especially customer service representatives) are literally plugged into a console at their desk to allow incoming phone calls to be answered while their hands are free to key in information.

The introduction of computers into the workplace has changed the nature of many clerical positions. Jobs that previously included a variety of tasks such as typing, filing, delivering memos and errands around the office now have become more homogeneous and restricted. Positions such as "data entry clerk" describe the activity of eight hours of work instead of one task among many.

TABLE 6

F. HEADACHES

The data presented in Table 6A (page 72) and Graph 6A (page 73) demonstrate an increased prevalence of headaches among workers who use VDTs seven or more hours per day for all industries combined. The prevalence of headache cases, those experiencing headaches almost always, was 0.14 or 14% among workers using VDTs seven or more hours per day compared to 0.10 among workers who did not work with VDTs at all. The prevalence ratio was 1.4 with a 90% Confidence Interval of 1.0 to 1.9.

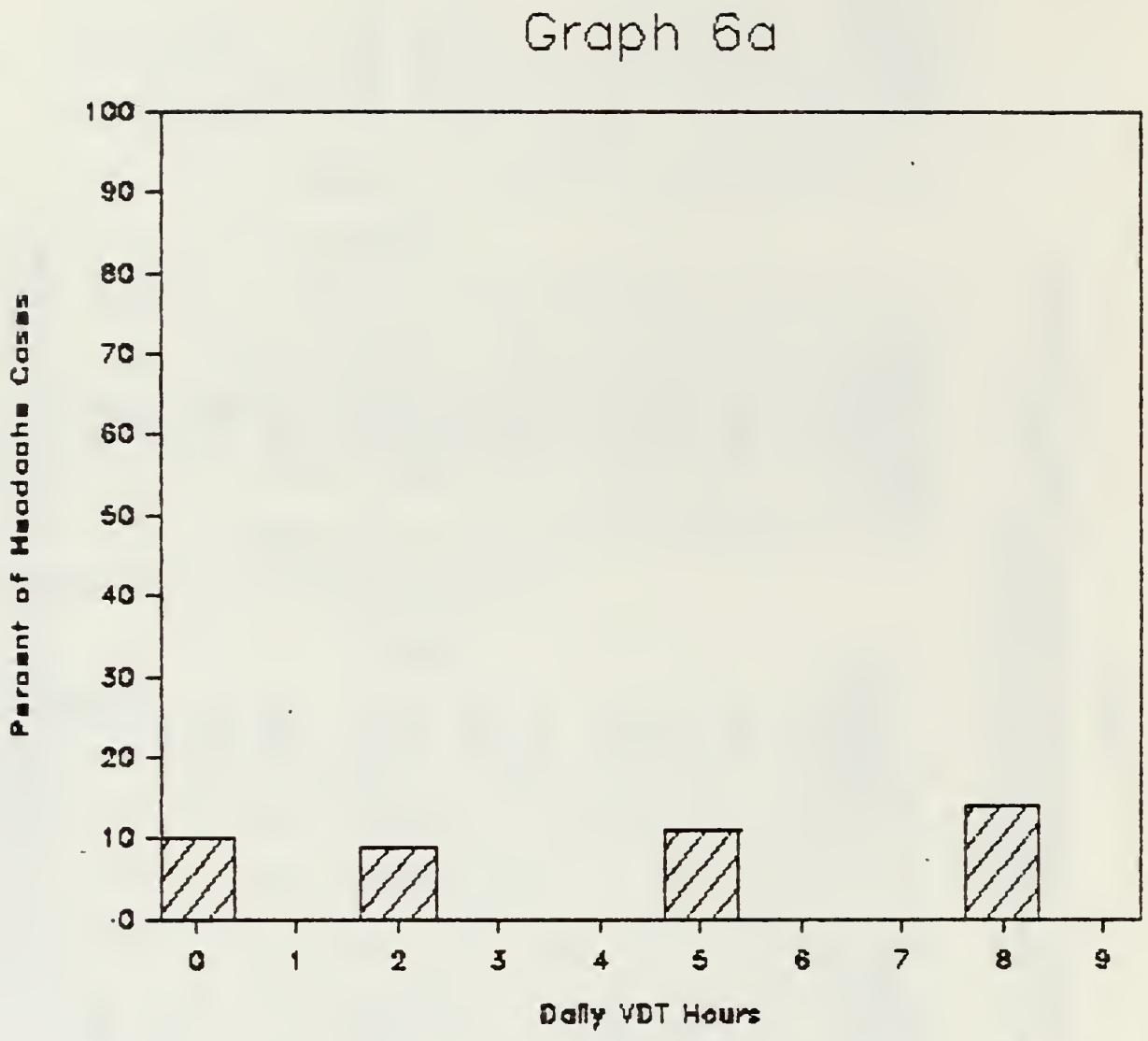
Table 6B (page 72) and Graph 6B (page 74) describe the results of the analysis of headaches in computer and data processing services, public utilities, and the Commonwealth of Massachusetts.

Table 6

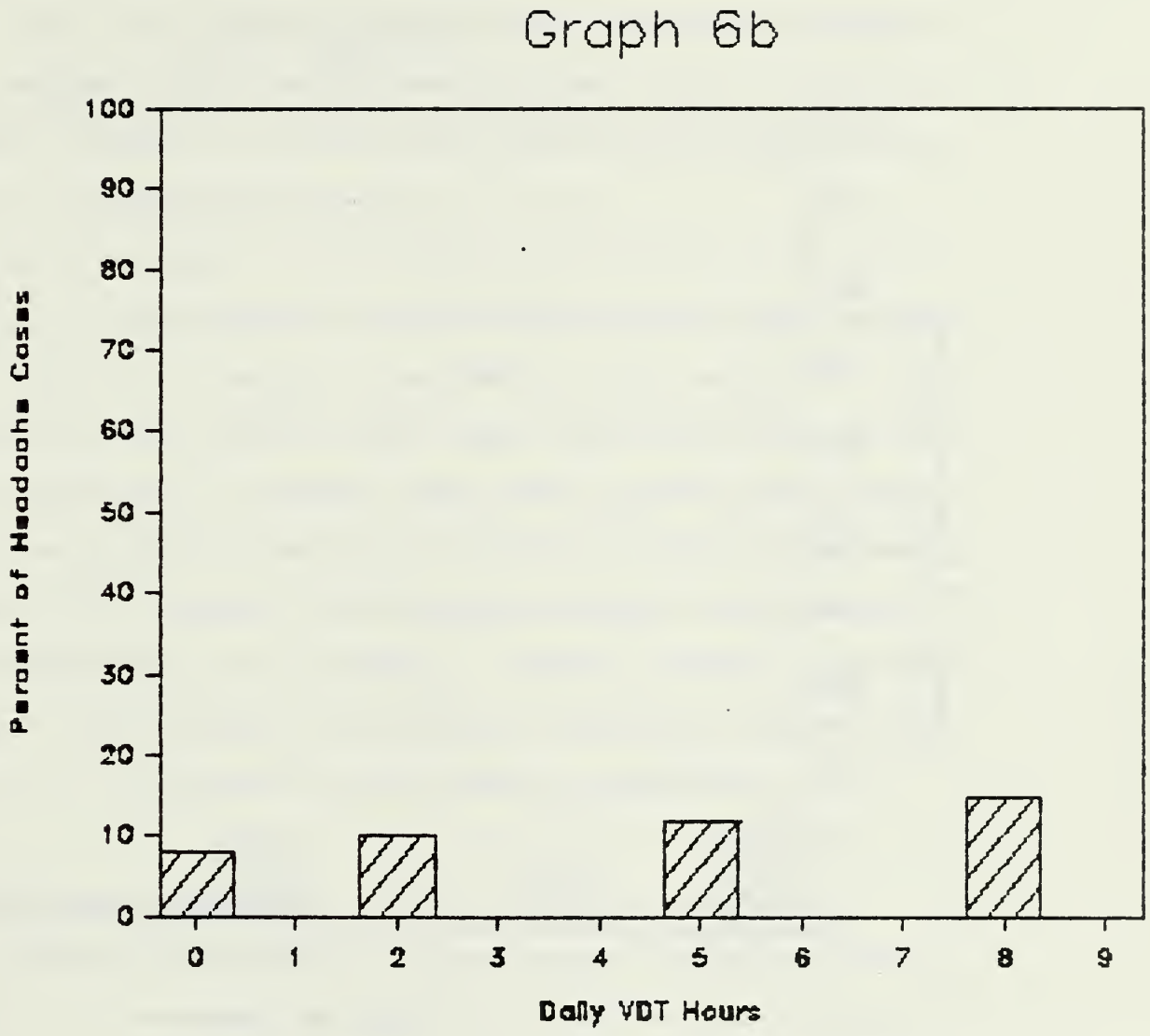
Number of Workers, Prevalence and Prevalence Ratios of Headache Cases Among Office Workers by Daily Video Display Terminal Use and Industry

	Industry	Daily Video Display Terminal Use (Hours)	Number of Workers	Prevalence of Headaches Cases	Prevalence of of Headache Cases (90% Confidence Interval)
A.	All	0	384	0.10	1.0 -
		1/2 - 3	432	0.09	0.9 (0.6 - 1.3)
		4 - 6	266	0.11	1.1 (0.8 - 1.6)
		7 or more	428	0.14	1.4 (1.0 - 1.9)
B.	Computer and Data Processing Services, Public Utilities, and Massachusetts State Depts.	0	199	0.08	1.0 -
		1/2 - 3	187	0.10	1.3 (0.8 - 2.3)
		4 - 6	156	0.12	1.5 (0.9 - 2.6)
		7 or more	332	0.15	2.0 (1.3 - 3.1)
C.	Banking, Communications,* and Hospitals	0	185	0.13	1.0 -
		1/2 - 3	245	0.08	0.6 (0.4 - 1.0)
		4 - 6	110	0.11	0.8 (0.5 - 1.5)
		7 or more	96	0.09	0.7 (0.4 - 1.3)

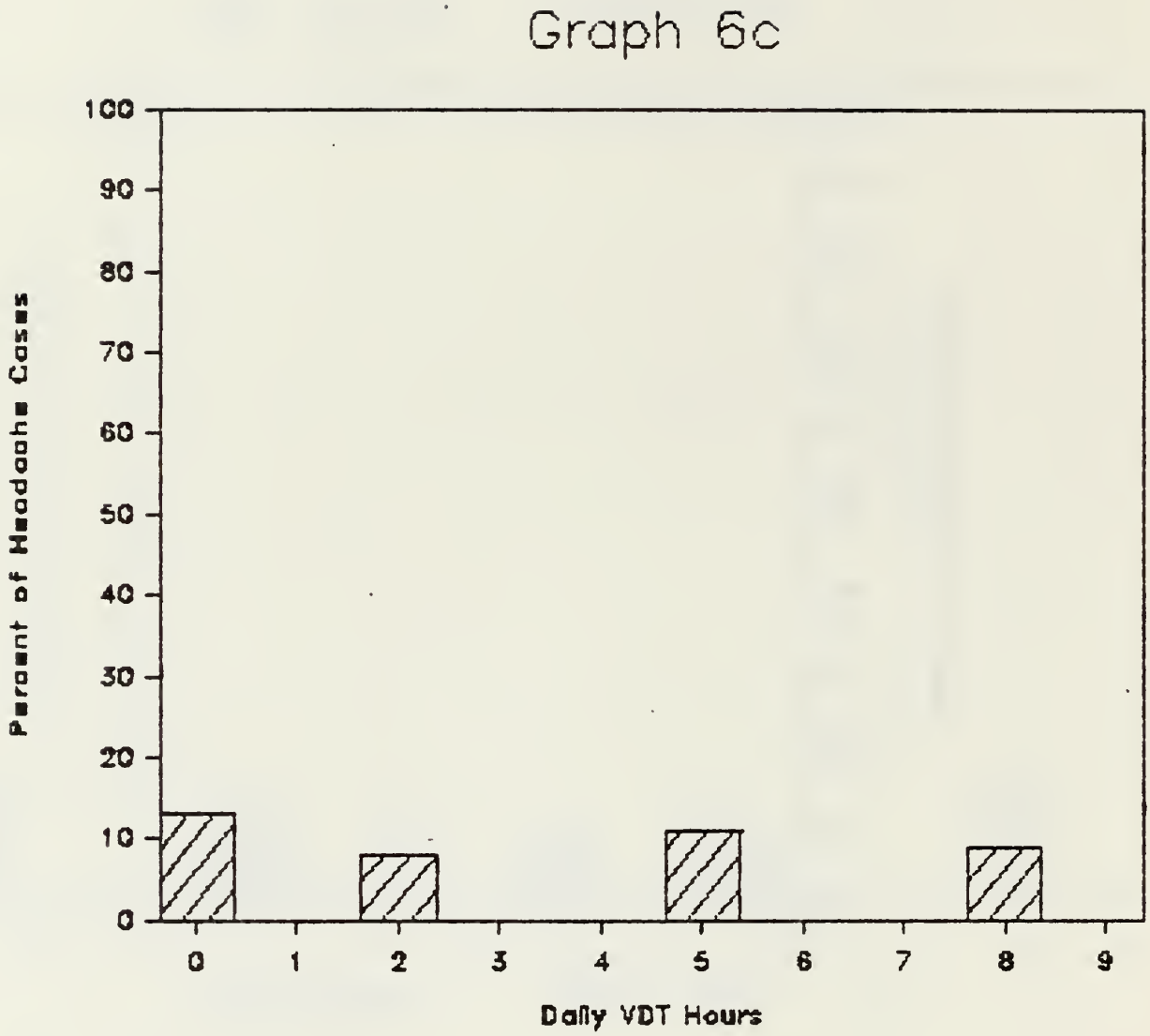
* Although the participation rate for industries in communications was 80 percent, the largest employer in this industry group, representing approximately 60 percent of all Massachusetts employees in communications, did not participate in the study.



Graph 6a: Percent of headache cases among office workers in all six industries by daily video display terminal use



Graph 6b: Percent of headache cases among office workers in Computer Services, Public Utilities, and the Commonwealth by daily video display terminal use



Graph 6c: Percent of headache cases among office workers in Banking, Communications, and Hospitals by daily video display terminal use

These data show a consistent increase in the prevalence of headaches among workers with increasing hours of VDT use. There is a doubling of the prevalence of cases among those who use VDT seven or more hours per day (Confidence Interval, 1.3 - 3.1).

Table 6C (page 72) and Graph 6C (page 75) show that a similar increase in the magnitude of the prevalence ratio was not observed for workers in banking, communications, and hospitals. The difference among industry groups seems partly attributable to the higher prevalence of headache cases among non-VDT users in these industries compared to the group of industries for which an increased prevalence was observed. This finding is similar to the results of the musculoskeletal case analysis: non-VDT clerical workers in banking, communications, and hospitals experienced a comparatively high rate of both headache and musculoskeletal conditions..

G. DISCUSSION: HEADACHES

Headaches are difficult to evaluate because they are subjective, difficult to describe, have multiple causes and are experienced commonly by many people. They may be related to exposures (chemical, physical or biological) or to other conditions (visual problems, musculoskeletal disorders). A headache may be a response to stress, be it job-induced or not.

Studies of VDT operators and comparison groups have resulted in widely varying reports of headache prevalence. These different

reports may be due to differences in study design and questionnaire format. Bergqvist (1984), in a review of the relevant literature, found that the reported incidence of headaches for VDT operators and referents varied from 11 to 89%. He also reported that some studies found an increased prevalence of headaches among VDT operators and other studies did not. One study found high prevalence rates (63 to 89%) of headaches in both groups (VDT and non-VDT) at all three sites in a NIOSH study; however, the study was conducted during heated labor negotiations (Murray, 1981). A study that failed to find a difference between VDT operators and controls, compared the number of people experiencing a headache at any time, and at any frequency during the past month (Starr, 1983).

The presented study analyzes headaches experienced "almost always", described as headache cases. The findings indicate an increase in headaches for VDT operators, regardless of the industry in which they are employed, who work seven or more hours per day. However, the differences between the two groups of industries are worth considering. While one set of industries (6B) shows a dose response curve, (increased prevalence of headaches with increased hours of VDT use), the other subset (6C) does not.

The difference among industries leads to further questions about a number of variables that could influence the incidence and duration of headaches. One variable that has been proposed as a source of vision-related headaches is frequent shifting of gaze from hard copy to screen display and keyboard, consistent with data entry work.

Smith, 1982, found a positive association between an "eye shifting" mode of VDT use and headaches, boring or dull in quality, located superficially, unilateral in origin and spreading bilaterally. Similar results were noted by Elias, 1980. In his study, headaches were reported more frequently by data acquisition workers than dialogue VDT workers. The differences in headache prevalence between industries may reflect differences in the predominant type of VDT work.

A second explanation could be differences in air quality and smoking policies that could influence the rates of headaches among all employees, regardless of VDT use.

Murray, 1981, did not find differences in headache prevalence between VDT operators and referents. However, he did find very different rates of headache prevalence in the three different sites, ranging from 14 percent and 10 percent for VDT and non-VDT clerical workers at one site, to 64 percent and 67 percent respectively at a second site.

Another variable that could explain differences among industries in headache prevalence is variation in stress that is related to factors such as diverse supervision styles, social support, unionization, income levels, deadlines, or timetables for clerical work. The many factors that have an impact on stress could not be addressed in depth by the present study. Analysis of questionnaire sections on job demands and job control, two aspects of stress that were investigated, is not complete. Plans are underway to submit the

findings on the stress portions of the questionnaire in a coded, computerized format to Dr. Robert Karasek, a researcher, at the University of Southern California, for comparison with the results from thousands of workers in other industries which he has compiled.

Given the apparently common experience of headaches among non-VDT users in hospitals, banks, and communications, further questions are raised about the nature of non-VDT clerical work and workers in those industries. Non-VDT clerical workers may be relegated to tasks such as medical records, telephone sales, billing, or other jobs which may be equally routinized and stressful (Brunt, 1983, Stellman, 1983a, 1983b). Or, it is possible that these clerical workers perceive their jobs as insecure, and not part of the forward-looking trend toward computerization. Recent articles have highlighted tendencies toward creation of more highly skilled computer programming jobs and the elimination of less skilled clerical positions (U.S. Department of Labor, Women's Bureau, 1985). Perhaps the fear of job loss contributes to the stress experienced by these clerical workers.

Given the scope of the present study, it is not possible to explain all of the findings; the explanations offered in the preceding paragraphs remain at the level of speculation.

Sources of stress are many and varied among all clerical workers. The Framingham Heart Study (1980), NIOSH (1980, 1981), and Fleishman (1984) were among the first to note that clerical work is a stressful job. The findings of headaches among both non-VDT and

all-day-VDT users, particularly in the second set of industries, highlights an area for further study. While several authors have commented on machine pacing, machine monitoring and the assembly-line nature of some VDT tasks as stressful (Brunt, 1983, Stellman 1983a), a number of other aspects of clerical work may also be stressful and strain-inducing.

Research by Robert Karasek has indicated that a combination of low decision latitude and demanding work is associated with mental strain. (Karasek, 1979). Work described as routine, repetitive, yet requiring "very fast work" and lacking rest breaks is high-demand. Job decision latitude is defined as the workers' potential control over her/his tasks and conduct during the day (Karasek, 1979). Clerical work seems to meet the description of high demand and low control that might lead to high strain. (U.S. Department of Labor, Women's Bureau, 1985).

TABLE 7

H. COLDS OR SORE THROATS

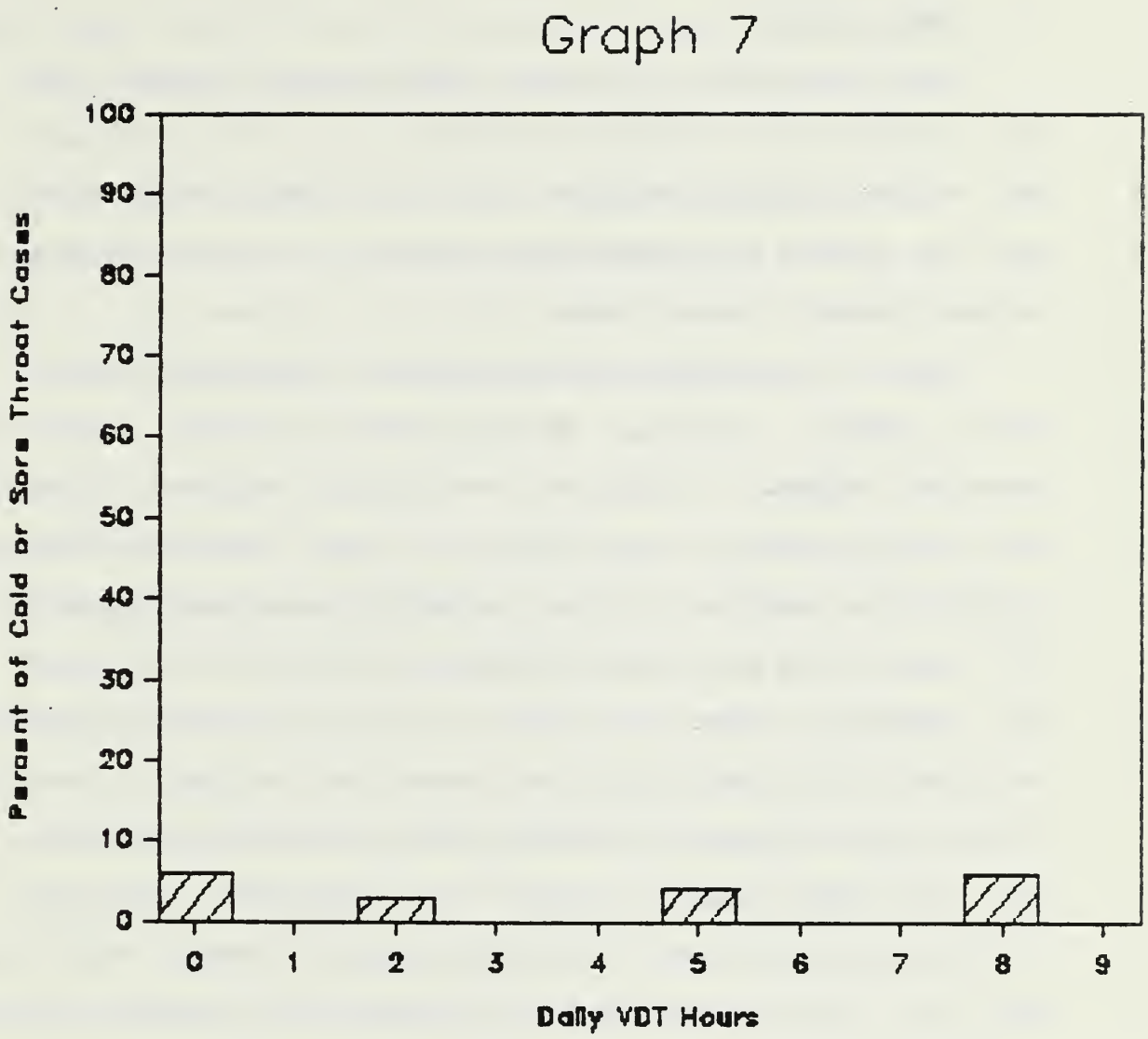
Table 7 (page 81) and Graph 7 (page 82) show that no consistent relation was observed between daily VDT use and the prevalence of cold or sore throat cases for all industries combined. The prevalence of colds or sore throats was markedly lower among subjects using VDTs three or fewer hours per day compared to non-users.

There was a relation between cold or sore throat cases and poor indoor air quality. An indepth description of the findings will be available in a separate report.

TABLE 7

Number of Workers, Prevalence, and Prevalence Ratios of Cold or Sore Throat Cases Among Office Workers by Daily Video Display Terminal Use in All Six Industries

Daily Video Display Terminal Use (Hours)	Number of Workers	Prevalence of Cold or Sore Throat Cases	Prevalence Ratio of Cold or Sore Throat Cases (90% Confidence Interval)
0	382	0.06	1.0 -
1/2 - 3	427	0.03	0.4 (0.2 - 0.8)
4 - 6	266	0.04	0.7 (0.4 - 1.2)
7 or more	420	0.06	1.0 (0.6 - 1.6)



Graph 7: Percent of cold or sore throat cases among office workers in all six industries by daily video display terminal use

I. OTHER VARIABLES

There were no large, consistent differences in the estimates for the prevalence ratios presented in Tables, 1, 3, 6, or 7 according to any of the following variables: age of the workers, whether or not they had attended a VDT educational training class, smoked cigarettes or wore glasses or contact lenses.

None of the studied medical conditions, (high blood pressure, heart disease, stomach or duodenal ulcer, arthritis, migraine headache, hayfever or allergies, bronchitis or emphysema, asthma, back or neck injury, arm, shoulder or hand injury) which have modified the evaluated outcomes, was strongly associated with daily VDT use, nor did any of these conditions markedly affect the size of the relations between daily VDT use and any of the outcomes evaluated. These latter relations, however, were difficult to assess because few subjects reported experiencing these medical conditions. The most common reported condition was hypertension, which was reported by eight percent of the subjects; the least common condition was arm, shoulder, or hand injury, which affected one percent of the subjects.

Discussion:

Prolonged hours (seven or more) of VDT use are strongly related and four to six hours are moderately related to an increased prevalence of adverse conditions related to vision and musculoskeletal systems, and to headaches. The relation is not necessarily causal. The findings suggest, that more VDT office

workers (using their VDT four or more hours per day) will experience more adverse health outcomes, than workers who do not use VDTs at all.

Of particular interest were the findings that use of a video display terminal 1/2 to 3 hours per day was associated with (1) no increase in the prevalence of vision, musculoskeletal or headache cases; (2) an unexplained decrease in the frequency of colds or sore throats, and (3) in one subset of industries (banking, communications, and hospitals), an apparent decrease in musculoskeletal cases. These results may reflect the complex issue of the organization of work. Tasks requiring 1/2 to 3 hours of VDT work, require 4 to 7 hours of non-VDT office work, and may be more diversified than jobs which do not involve VDT use or jobs that require 7 or more hours of VDT use. The findings may also reflect the increased flexibility and control that may accompany diversified work activities. In addition, the VDTs in these situations may be perceived as a useful technological adjunct to work rather than as the factor that controls the structure of work activity.

ERGONOMICS

ERGONOMICS

Although the research conducted for this study indicated the importance of ergonomics in relation to VDT use, it was recognized that an in-depth ergonomic study would require a larger amount of staff and finances than the amount appropriated by the legislature for this study. It was therefore decided that a pilot test of a small number of worksites would be conducted with the primary purpose of developing tools for ergonomic measurements of VDT workstations and surrounding areas, should a more extensive study be conducted at a later date.

As a result of this pilot test, it was agreed that if an ergonomic study was conducted, the survey would include evaluations and measurements of variables associated with: (1) characteristics of the terminal itself, (2) variables related to the individual operators, and (3) factors associated with the workstations and the surrounding areas. An evaluation and comparison of the workstations of those VDT operators who reported the most and the least visual and musculoskeletal symptoms in the health survey would be important.

Variables associated with characteristics of the terminal would include identification of physical properties such as character images, screen size and colour of characters, glare, reflection, the manufacturer of the terminal, the identification number and the year it was produced. Variables related to the individual operators would include observations of the sitting position or posture of the

operator, placement of the wrists on the keyboard, the percentage of work-time the operator views the screen, the keyboard, and the document when using the terminal as well as the viewing distance from the operator to the screen. Dynamic methods, such as videotaping the operators at work with subsequent scoring by ergonomists to evaluate the physical stressors would be especially helpful.

Factors to be measured and evaluated relating to the workstations, work areas, and overall room would include the type of room lighting, the number and location of windows and shades, curtains, drapes or the absence thereof. Measurements of the height, depth, thickness and adjustability of tables, chairs, keyboards and other VDT equipment and furniture would be taken.

Other options that would be helpful include a subjective evaluation completed by each operator to obtain his/her opinion of the suitability and comfort of lighting factors, glare, screen brightness and control, chair, table, keyboard and other factors related to their job tasks and to the job design.

R A D I A T I O N

RADIATION

Introduction:

One of the more worrisome of the concerns raised about VDTs involves the possibility of radiation hazards. A major component of a VDT is the cathode ray tube (CRT), which consists of an electron gun, focusing lens system, an electromagnetic deflection arrangement and a phosphor coated screen. Radiation may be produced as a result of the relatively high voltage applied to the anode of the cathode ray tube, and because of the interaction between high speed electrons that are generated and the phosphorescent materials on the CRT screen. Additionally, VDTs have power supply components which, if not appropriately shielded, have the potential to be a source of radiation, just as exists with a television set.

The Food and Drug Administration (FDA) Bureau of Radiological Health (BRH) published a study in 1981 which found that a number of older VDT models in use during the 1970's emitted measurable levels of ionizing radiation (x-rays) during conditions of extreme malfunctioning in excess of that allowed under the television receiver standard. FDA reported, however, that these models have been corrected or withdrawn from the market. FDA set forth the conclusion that "--video display terminals should not pose a radiation risk to those who operate them." The fact that the FDA's Bureau of Radiological Health (BRH) published a study reporting that several models of VDTs had emitted ionizing radiation reappeared

again and again in the popular literature about VDTs.

Evaluation of the radiation hazard of VDTs was undertaken because of radiation's known hazards, poor warning properties and the findings of the Bureau of Radiologic Health. Sources, effects and shielding of ionizing and nonionizing radiation are poorly understood by the general public. It was decided to measure radiation levels on VDT's produced by several different manufacturers of video display terminals, especially on a number of those terminals where operators were experiencing increased vision or musculoskeletal problems. The intent was to investigate radiation as a hazard in a worst case use scenario. In other words, the terminals evaluated were those used all day by one person who qualified by study definition as a vision or musculoskeletal "case". For comparison purposes, an equal number of terminals were tested whose operators were matched to cases for age, sex, employer, and hours of VDT use but did not experience symptoms "almost always", or "frequently".

RADIATION - DESCRIPTION OF TYPES

Radiation is a general term used to describe the emission or propagation of energy through space or through a material, in the form of particles or waves. It may be in the form of electromagnetic waves or corpuscular emissions.

The former is usually classified according to frequency - e.g. Hertzian, infrared, (visible) light, ultraviolet. See Figure 1 (Bureau of Radiological Health, 1981) on the following page.

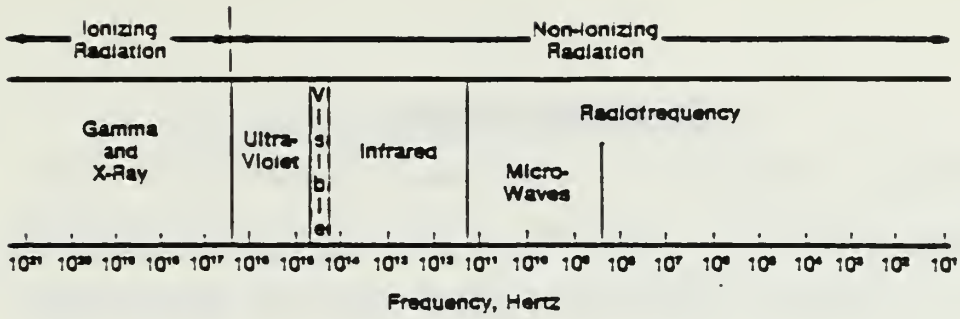


Figure 1. Regions of the electromagnetic spectrum as a function of frequency in hertz. The divisions between regions are approximations, as an exact division cannot be defined.

(Bureau of Radiological Health, 1981)

IONIZING RADIATION

Ionizing radiation is radiation which is capable of dislodging an electron from an atom or molecule thereby producing ions. Examples of ionizing radiation are alpha and beta particles, protons, neutrons, gamma and x-rays, and all other radiations which produce ioniziation directly or indirectly.

"Low energy x-rays can be generated in the cathode ray tube and the shunt regulation tube if they are operated at a sufficiently high voltage". (Moss, 1977). Normal functioning VDTs do not emit levels of x-rays above normal background levels, because this radiation "can be controlled by proper circuit design and by the use of certain shielding methods in or around the CRT". (Bureau of Radiological Health, 1981). X-Rays produced inside a CRT used in a VDT are generally of low energy, and are not very penetrating. Such X-rays are effectively filtered by the glass or other material that is installed as part of the VDT cabinet. This is especially true where the anode voltage applied to the CRT is 16 kilovolts or less, which is generally the case for VDT's in current use.

NON-IONIZING RADIATION

Non-ionizing radiation is electromagnetic radiation which does not produce ionization. Examples of non-ionizing radiation are microwaves, infrared, ultraviolet, visible light, and radiofrequency radiation.

> "Acute biological effects are expected when the radiation exposure is sufficient to cause a rise in temperature of tissue. It is possible that more subtle immediate effects, which may not be thermal in nature, also occur. Evidence exists that radiation frequency dependent effects are possible particularly in the microwave, visible and ultraviolet portions of the spectrum." (Bureau of Radiological Health, 1981).

Thermal effects are a function of body absorption rates. This in turn is frequency dependent. Maximal whole body absorption is reported to occur at a frequency near 70 Megahertz where the wavelength (4.28 meters) is approximately 250% of the long axis of the average person. In the case of VDT's the worst case scenario appears to be radio-frequency emission at 16 kilohertz where the wave length is 18750 meters. Because of this extended length, an individual would sustain a much lower absorption rate since the length of their body is relatively short in contrast with the wavelength at 16 KHz. In other words whole-body resonance does not occur at 16 kHz (See ANSI C95.1-1982).

RADIATION--INSTRUMENTS AND PROCEDURES

The instruments that were used to test for radiation emissions were selected for the following reasons: (1) similarity to models used by NIOSH (National Institute for Occupational Safety and Health) in their health hazard evaluations and studies so that our measurements could be compared to their published findings; (2) portability, or use as field instruments as opposed to laboratory instruments; and (3) appropriate sensitivity and coverage of a broad range of frequencies.

The instruments used, frequencies covered and sensitivities were as follows:

NON-IONIZING RADIATION

a) Holaday Industries, Inc., Isotropic Broadband Field Strength Meter, Model 3002, S/N 39177 with "E" field probe, S/N 623 and "H" field probe S/N 355, Frequency coverage of "E" field probe is 0.5 MHz to 6 GHz and 5 MHz to 300 MHz for the greenband "H" field probe, and 500 KHz to 10 MHz for the black banded "H" field probe. "E" field stength sensitivity of instrument is 500 $(V/m)^2$ and 0.005 $(A/m)^2$ with respect to the "H" field.

b) General Microwave Corporation, Radiation Hazard Meter Model 2, S/N 122573 with RAHAM "E" field probe Model 82, S/N 122949. "E" field probe responds to electric field in the frequency range 10 MHz to 3 GHz. Instrument sensitivity is equal to 0.1 mW/cm^2.

c) Instruments for Industry, Inc., E-field sensor Model EFS-2, S/N 305-C which responds to electric fields between 10 kilohertz and 220 Megahertz. The EFS-2 is supplied with 3 antennae which, in combination with the front panel meter scale switch provide full scale sensitivity ranges from 3 V/m. Maximum sensitivity is 1 V/m.

d) International Light, Inc., Research Radiometer and Photometer Model IL730A S/N 1636 which measures energy or power density from ultraviolet and visible radiation. Attachments included Detectors: actinic UV Detector SEE240 S/N 1681, UV Detector SEE015 S/N 1745, Visible Light Detector SEE400 S/N 1379; Diffusers: R#141 and W#2706; and Filters: BR#4113, UVA#4030 and Y#4248. Maximum sensitivity is 1.0×10^{-15} watts/cm^2

IONIZING RADIATION

e) Victoreen Model 440 RF/C, Radiation Exposure Rate Measuring System, S/N 2804 is designed for the measurement of low intensity gamma and X-ray radiation levels or as a beta detector. This instrument has a sensitivity of 0.1mR/hr.

The procedure for detecting ionizing radiation with the Victoreen 440 RF/C consisted of scanning all surfaces while the VDT was operating and the screen was at least 2/3 covered with alphanumeric symbols. A range of values (with the units of mR/hr or thousandths of a Roentgen per hour) was recorded for each surface (front, left, right, top, and back) measured at a distance of 1 -2 inches, as well as a background reading and a measurement at the operator position for each VDT evaluated. (See attached Radiation Field Data Collection Sheet, Appendix V).

There were four instruments used to evaluate different portions of the electromagnetic spectrum for non-ionizing radiation. Surveys using the following equipment should be considered semi-quantitative screenings since they cannot follow rapid changes in peak intensity and may underestimate peak values of field strengths. No instrumentation was available to evaluate magnetic (H) field strength except for the range 500 kHz to 300 MHz covered by the Holaday Industries, Broadband Field Strength Meter, Model 3002.

The Instruments for Industry, Inc., E-field sensor Model, EFS-2 which measures electric field forces in the radio frequency range including VLF, LF, MF, HF, and VHF. This instrument responds to electric fields at frequencies as low as 10 kHz. These measurements were made using the more sensitive (5 inch) antenna. All surfaces were scanned at a distance of 1 - 2 inches, and maximum readings recorded for each of 3 orthogonal axes of the antenna. Measurements were recorded at the operator position as well. The units of measurement were root mean square (RMS) values of volts per meter. RMS is equal to 70.7% of the peak value.

The RAHAM Model 2 or Broadband Electromagnetic Radiation Hazard Meter measures electric field power density in units of mW/cm^2 (milliwatts per square centimeter). The RAHAM detects radio frequency and microwave radiation between 10 MHz and 3 GHz. Average and maximum values were recorded for each surface and the operator position after scanning with the instrument probe touching the surface.

The Holaday Model HI 3002, Isotropic Broadband Field Strength Meter provided the capability of detecting and measuring magnetic (H) as well as electric (E) field strength. The units were read as field strength units squared (FSU^2) which would be A^2/m^2 (amperes squared per meter squared) for H field and V^2/m^2 (volts squared per meter squared) for E field. These units can be converted through mathematical calculations to power density values in milliwatts per square centimeter. Average and peak values were recorded for each accessible VDT surface and at the operator position.

The last instrument for measuring non-ionizing radiation was the International Light Photodetector/Radiometer. This instrument was used to measure for ultraviolet (average wavelength 270 namometers), near ultraviolet (average wavelength 355 namometers), blue light hazard and visible light emissions. The ultraviolet and blue light measurements were conducted with the VDT operating and the screen at least 2/3 filled with letters and/or numbers; the detector was held up against the screen and the value recorded in units of watts per square centimeter. Visible light measurements were made with the VDT off, or with the contrast turned all the way down. These measurements provided a mathematical approximation of reflected light or glare, as recorded at a normal viewing distance. First, luminance was recorded with the screen hooded, to prevent any reflections, in order to ascertain any background level of light from the CRT, phosphorescent screen or light passing through from the rear of the machine through the enclosing cabinet. Then, a range of values was recorded representing the observor's assessment of the darkest and the lightest portion of the screen, in units of foot lamberts.

Measurements, in units of foot candles were also recorded of light incident on the keyboard, on paper set close to the VDT and at the operator position using a GE light meter.

The above measurements are in accordance with manufacturer's instruction manuals and with procedures used in NIOSH studies. (Moss, 1977 78-129 and Murray, 1981 81-129).

The average evaluation of one terminal took approximately 45 minutes to an hour, excluding warm-up time for several of the instruments.

TERMINALS EVALUATED

The following is a list of the names of the manufacturers of the terminals and the respective numbers evaluated during this phase of the study.

Manufacturer Name	Model	Number
Burroughs	TD015	2
CPT	8100	1
General Computer Systems		2
General Computer Systems	IV	2
IBM	3278-4	1
IBM	3278-2	1
ITT	1700-D	3
Nixdorf	161A	2
Olivetti	BCS2030	1
Sperry/Univac	UTS 20	6
Sperry/Univac	UTS 40	1
Sperry/Univac	UTS 400	1
Wang	2246C	1
Wang	5536-4N	1

Totals: 25 VDT terminals from 9 manufacturers.

Results

Ionizing Radiation

Values measured ranged from 0 to 0.15 mR/hr, with one momentary value of 0.36 mR/hr that was not repeated on a recheck. None of the 25 VDTs tested emitted X-radiation above 0.5 mR/hr., the TV receiver emission limit prescribed by federal regulations for the administration and enforcement of the Radiation Control for Health and Safety Act of 1968. The vast majority of the readings were indistinguishable from background.

Discussion

There have been several clusters of adverse reproductive outcomes including stillbirths, miscarriages and birth defects reported among VDT operators (Tuthill, 1985). Efforts to identify the cause of these clusters have been unsuccessful. It is believed that ionizing radiation was not a cause in the reported clusters because levels of X-rays above background were not detected on subsequent investigations of several of the clusters. Besides the BRH, FDA study, there have been no reports of elevated levels of ionizing radiation. In the present study as well, the VDTs were not observed to emit ionizing radiation.

The following paragraphs from the Bureau of Radiological Health report, "An Evaluation of Radiation Emission from Video Display Terminals," February, 1981, are helpful:

Sufficient research information is available to estimate a range of risks of injury from ionizing radiation exposure. Delayed disease, such as heritable mutation or cancer, usually forms a basis for the estimation, expressed in terms of the instances of the effect per person per unit of radiation (rad, rem, or R). The risk estimates form a basis for radiation protection guidelines.

For a VDT operator, the radiation protection guideline for individuals in the general population is appropriate. The guideline--500 millirem per year--is for man-made radiation exposures excluding medical use. For both normal and Phase III operating conditions, the likely emission from a VDT is 0.1 mR per hour or less. Terminals capable of exceeding the 0.5 mR per hour regulatory limit receive special attention. With assumptions of 6 hours of viewing per day, 5 days per week for 50 weeks per year, the annual radiation dose to an individual 2 inches from the front surface of a screen emitting 0.1 mR per hour would be 150 millirem. Note that 2 inches is an unrealistically short viewing distance; as one moves further away from the screen, the radiation exposure decreases correspondingly.

If the same calculations are done with the level of viewing observed in this study, i.e. 8 hours per day, the final result is 200 mR/year at 2 inches distance, still well below the guideline for exposures in the general population.

Results

Non-ionizing radiation

The only national standards for workplace exposure to non-ionizing radiation in the range 10 kHz to 300 kHz are Threshold Limit Values, or guidelines recommended by the American Conference of Governmental Industrial Hygienists. They are: 100 mW/cm^2 power density, 377,000 V^2/m^2 (614 V/m) electric field strength and 2.65 A^2/m^2 (1.63 A/m) magnetic field strength. These TLVs were set "to protect against shock and burn hazards." However, the first note

following the text states, "All Radiofrequency Radiation (RFR) exposures should be kept as low as reasonably possible given the current state of knowledge on human effects, particularly non-thermal effects." Similar standards have been promulgated for NIR (non-ionizing radiation) workers in the Commonwealth of Massachusetts.

In addition, the Massachusetts Department of Public Health has regulations - (105 CMR 122.000) governing radiofrequency exposure limits for public exposures. In general, the public exposure limits are one-fifth the ANSI (American National Standards Institute) C95.1-1982 Protection Guides. VDT operators should be covered under these public exposure guidelines since they do not meet the criteria for a NIR (non-ionizing radiation) worker. The DPH 105 CMR 122.000 covers exposures from 300 kHz to 100 GHz; Table 1 is cited below.

TABLE 1
RADIO FREQUENCY EXPOSURE LIMITS FOR PUBLIC EXPOSURES*

Frequency Range	Maximum Allowed Mean Squared Electric Field Strength $(V/m)^2$	Maximum Allowed Mean Squared Magnetic Field Strength $(A/m)^2$	Maximum Allowed Equivalent Plane Wave Free Space Power Density** (mW/cm^2)
300kHz-3MHz	80,000	0.5	20.0
3MHz-30MHz	$800(900/f^2)$	$0.005(900/f^2)$	$180/f^2$
30MHz-300MHz	800	0.005	0.2
300MHz-1500MHz	$800(f/300)$	$0.005(f/300)$	$f/1500$
1500MHz-100GHz	4,000	0.025	1.0

As used in Table 1:
f = frequency in megahertz (MHz)
V = voltage in volts
A = current in amperes
m = length in meters
cm^2 = area in square centimeters
mW = power in milliwatts

For mixed or broadband fields consisting of a number of frequencies for which different Radio Frequency Protection Guides are listed in Table 1, the fraction of the Radio Frequency Exposure Limits incurred within each frequency interval shall be determined, and the sum of all such fractions shall not exceed unity.

* These are average values over any 0.5 hour period. See 105 CMR 122.090 Appendix A. This table does not apply to microwave ovens, refer to 105 CMR 122.040.

** See 105 CMR 122.090 Appendix A for calculation of equivalent plane wave free space power density in the non far field region.

If the 1/5 rule is extrapolated to the ACGIH Threshold Limit Value between 10 kHz and 300 kHz, then the recommended limit for maximum public exposure would be 20 mW/cm^2 (equivalent to mean square electric field strength of 275 V/m).

Values measured with the EFS-2 ranged from 0 - 9.1 V/m for 23 of the VDTs. On the two ITT models values as high as 140 V/m were measured on the left side at a distance of 1-2 inches, on the z axis. At the operator position, the highest value recorded was 5.5 V/m (also on the ITT). If the extrapolated public exposure guidelines are used to evaluate these findings, the highest reading at 1-2 inches is 49% of the guideline and, at the operator position, it is 2% of the guideline.

Values measured with the RAHAM Model 2 ranged from 0 to 0.5 mW/cm^2 for 23 of the 25 VDTs evaluated. On two GCS (General Computer Systems) models, values as high as 10 and 11 mW/cm^2 were measured on the top near the left rear corner, over a small area.

Measurements for these two GCS VDTs as well as for all the other VDTs, were 0 at the operator position.

Because of the unusual readings recorded at the two GCS models, three other GCS terminals were evaluated with the RAHAM Model 2 at a later date. Maximum readings were 8 mW/cm^2, 9 mW/cm^2 and 20 mW/cm^2 measured on the top surface near the left rear corner over a small area. These values fell off to 4 mW/cm^2, 5 mW/cm^2 and 10 mW/cm^2 at 2 inches respectively. At three inches distance,

values measured were less than minimal detectable level, 0.6 mW/cm^2 and 3 mW/cm^2 respectively. No detectable level was observed at the operator positions for the three machines.

Three probes were available for use with the HI-3002: a black-banded probe for magnetic field strength from 500 kHz to 10 MHz; a green-banded probe for magnetic field strength from 5 MHz to 300 MHz; and a red-banded probe for electric field strength from 500 kHz to 500 MHz.

Results obtained with the black-banded probe are suspect because the probe was subsequently found to be malfunctioning. For 10 of the VDTs, values of 0 were recorded for all measurements.

The red-banded probe was not used because it covered the same range of frequencies as the RAHAM Model 2 (and overlapped with the IFI, EFS-2).

Values obtained for magnetic field strength (5 MHz to 300 MHz) ranged from 0 to 0.016 $(A/m)^2$ for peak hold readings. The RF Public Exposure Limits for H field readings are 0.005 $(900/f^2)$ $(A/m)^2$ from 3 to 30 MHz and 0.005 $(A/m)^2$ from 30 - 300 MHz. The maximum value recorded at the operator's position was 0.005 $(A/m)^2$, the exposure limit, also as a peak hold reading. Peak hold readings represent transient fluctuations and peaks. The manufacturer recommends considering the actual meter indicator as a more suitable reading of a time-averaged evaluation of exposure. The average meter indication was lower, in every case, than the peak hold reading.

Because of the unusual readings noted before at the GCS terminals further evaluation was conducted at three additional GCS terminals with the HI-3002. Electric field stength, E^2, measurements are tabulated as follows:

	System 2 Terminal 15		System 2 Terminal 21		System 1 Terminal 8	
(V^2/m^2)	Ave	Peak	Ave	Peak	Ave	Peak
Screen	$5x10^3$	$6.5x10^3$	$3.5x10^3$	$4.0x10^3$	$6x10^3$	$7x10^3$
Keyboard	0	$4.0x10^3$	0	$1.8x10^3$	0	-
Operator	0	$0.5x10^3$	0	$0.5x10^3$	0	-
Right side	$0.5x10^3$	$1.5x10^3$	$0.5x10^3$	$0.5x10^3$	$1x10^3$	-
Left side	$5.0x10^4$	$5.5x10^5$	$3.0x10^4$	$3.0x10^4$	$3x10^4$	$3.5x10^4$
4" from left					$4x10^3$	$7.0x10^3$
Top	-	-	$4.0x10^5$	$8.5x10^5$	$5x10^5$	$9.5x10^5$
1" from top	-	-	$1.0x10^5$	$1.0x10^5$	$2x10^5$	$4x10^5$
4" from top	-	-	$0.5x10^5$	$0.7x10^5$	$0.5x10^5$	$1.4x10^5$

Several of these readings exceed the Department of Public Health 105 CMR 122.015 Exposure Limits for Public Exposures in the range 300 kHz to 3 MHz. The limit for public exposure over that range is 80,000 V^2/m^2. The range covered by the H1-3002 with the red-banded E field probe is up to 6 GHz. The public exposure limit drops from 80,000 V^2/m^2 to 800 ($900/f^2$) with f in MHz for 3 MHz to 30 MHz and 800 V^2/m^2 for 30 MHz to 300 MHz.

The readings that were over 80,000 V^2/m^2 were: peak hold readings on all 3 terminals, on the left side of Terminal 15 and on the top, near the left rear corner for the other 2 terminals. The meter recorded <u>average</u> readings over 80,000 V^2/m^2 on the top, over a small area, up to one inch distance from the surface of Terminal 21. At four inch distance all but one peak hold reading had dropped below 80,000 V^2/m^2.

It should be noted that the readings at the operator position, at the keyboard, and measured at the back of the person seated in front of Terminals 15, 21 and 8 were all 0 for average readings. Peaks, however, as high as 500 V^2/m^2 at the operator position and 4000 V^2/m^2 at the keyboard were observed. These values are well below the public exposure limits.

It was decided to have one of the GCS terminals evaluated by a Federal Laboratory, by authority of the Television Products Section (HF2-312), Consumer Industrial Product, Center for Devices and Radiological Health. These tests were conducted at a Federal Engineering and Analytic Center. Their report states, "No readings in excess of any applicable standard were detected."

To summarize the VLF findings, only one model of VDT from one manufacturer (GCS) had VLF radiation levels in excess of any exposure guideline. The areas where these high levels of RF were measured were small, and located on the top, near the left corner, probably

near the fly-back transformer. Measurements at the operator position were 0 for the 3 terminals with peak hold readings of 500 $(V/m)^2$.

The GCS terminals were older models and probably lacked RF Shielding that is provided in most later models. In 1979, the Federal Communications Commission, FCC, began regulating the amount of electronic leakage permitted in new electronic equipment, not necessarily for health reasons, but because VLF radiation can interfere with the normal operations of computers and other equipment. Leaking VLF is also believed decodable, thus creating a security risk. However, millions of unshielded VDTs are still in use.

It is relatively easy to shield a VDT against VLF radiofrequency emissions. Shields made of metal grids or paints and plastics doped with metal, conduct away the electric field through a grounding wire to the chassis of the terminal. Several methods of shielding are summarized by Tarlau in a factsheet included in the Women's Occupational Health Resource Center (WOHRC) News, April/May 1985 Vol. 7 No. 1. This fact sheet states, "While we don't know that VLF is a hazard, we do know many VDTs can be easily modified...to eliminate VLF." In the absence of conclusive data implicating VLF as an occupational hazard, she recommends minimizing the exposure, taking a cautious approach. The same advice would be prudent in regards to the GCS terminals; work practices should be instituted to guard against leaning over the top of the terminals, or shielding

should be provided for the GCS terminals at this location, and for other unshielded video display terminals.

The final part of the radiation evaluation was of ultraviolet (UV) radiation, blue light and visible light reflections. The readings for far ultraviolet (UV) (average wavelength of 270 nanometers) were 0 for all the terminals. The readings for near UV (average wavelength 355 nanometers) ranged from 0 to $4.95 \times 10^{-7} W/cm^2$. Compared to the ACGIH, Threshold Limit Value of 1 mW/cm^2, the highest reading was 2000 times below the safety limit. The readings for blue light hazard (average wavelength 450 nanometers) ranged from 5×10^{-10} watts/cm^2 to 9.9×10^{-8} watts/cm^2, again well below any standard. The photodetector was also used to estimate the luminance of reflected light from various VDT screens. The aim was to quantify the light reflected as an evaluation of the glare hazard. The luminance of reflected light ranged from 0.38 to 18.5 foot lamberts. We were unable to gather sufficient data to compare vision cases to vision controls in terms of reflected light. The values recorded seemed to vary with manufacturer and with work site. For example, all the GCS terminals had very dark backgrounds with a maximum luminance reading of 1.90 (investigator wearing a white shirt), while all the Sperry/Univac terminals in one location had reflections which ranged from 1.8 to 7.9 foot lamberts. Nor did these readings give an evaluation of readability. While the GCS had the darkest background, which should

enhance contrast, the alphanumeric display was blue and the letters and numbers had a visible dot structure. "As the spacing between dots or elements increases, the reading time and reading difficulty increase." (National Research Council, 1983)

Using the visible light readings, we were unable to assess the multiplicity of visual factors that have an impact on readability. Video Displays, Work and Vision, published in 1983, gives an indepth review of VDT visual variables such as blur, resolution, temporal instability, and other factors. Glare, specular and diffuse reflections may be better evaluated by a trained office worker or safety and health officer, who could recommend ways to reduce reflections without actually measuring the amount of luminance involved.

SUMMARY AND CONCLUSIONS: RADIATION

IONIZING RADIATION

No ionizing radiation was detected at VDTs above the background level.

This finding was expected, as explained in the pamphlet published by the Canadian Environmental Health Directorate Health Protection Branch, entitled, "Investigation of Radiation Emissions from Video Display Terminals," because with the relatively low operating voltages of VDTs, the X-rays produced inside the CRT are of low energy and are not very penetrating. These X-rays are absorbed by the glass of the CRT and do not penetrate to the outside. In

fact, the thickness of glass used in the CRT has much higher X-ray shielding properties than required for the voltages at which VDTs operate and is capable of absorbing X-rays of energies considerably higher than those produced in the CRT. The results of X-ray measurements confirm this statement.

These same results (of VDT's X-ray radiation levels not exceeding background levels) were also found by NIOSH in 1975 and 1977 studies, by Weiss and Peterson at Bell Telephone Laboratories (1979) and in several Canadian studies presented in the pamphlet cited in the preceding paragraph. The present study adds to the evidence that VDTs do not emit ionizing radiation.

NONIONIZING-RADIATION

"The source of RF in a VDT is the horizontal deflection system, which causes the electron beam in the CRT to move across the fluorescent screen, and its associated high-voltage circuit, the so-called 'fly-back' transformer." (Canadian Environmental Health Directorate, 1983). The rapid pulsing on and off of the voltage gives rise to electrical and magnetic fields in the vicinity of the fly-back transformer and its associated circuitry. The radiofrequency radiation is produced at the fundamental frequency of the deflection system, 15 to 25 kHz and at harmonic frequencies.

In most of the VDTs evaluated in this study, the electric field at the VDT surface was below 0.5 mW/cm^2 (as evaluated by the RAHAM in the range 10 MHz to 3 GHz) and below 9.1 V/m (as measured by the

IFI, EFS-2 in the range 10 kHz to 220 MHz). These values are well below the DPH public exposure guidelines, and much lower power density and field strengths than any that have been postulated to have adverse health effects. It is believed that values measured are harmonics of the fundamental frequency of approximately 15 kHz.

For all of the VDTs, readings taken at the operator position ranged from 0 to 5.5 V/m, and most of the terminals yielded readings at the operator position below 1.4 V/m. These values are very small, much lower for example than RF energy that is emitted from RF sealers and heaters. Thus, the study provides no evidence suggesting that VDT operators are exposed to significant levels of RF radiation.

Two models of VDTs, ITT and GCS, had readings higher than the other models. The GCS models each had a small area on the top cabinet surface where E field readings exceeded extrapolated public exposure guidelines. Given the literature that exists on RF/microwave and ELF hazards, it is difficult to interpret the significance of these findings. Until further research is done regarding nonthermal effects of very low dosage exposures to this type of non-ionizing radiation it will be impossible to say with certainty that VDT's pose no hazard to office workers who use them. In the meantime, shielding VDTs for RF radiation can be recommended as a cautious approach. Even without shielding, the RF field falls off to 0 at the operator position.

Other aspects of the non-ionizing radiation survey indicated no

exposures to near ultraviolet, far ultraviolet or blue light hazard. Any radiation detectable was many orders of magnitude below levels known to cause harm.

And, finally, a trained eye may be more useful in determining glare, specular and diffuse reflections and the visual comfort of a VDT setting rather than a quantitative evaluation of the luminance. The visual comfort of video display terminals may be one of the most important aspects to consider in light of the increased prevalence of vision conditions and headaches with increased hours of VDT use found in this study.

STRENGTHS AND LIMITATIONS OF THE STUDY

STRENGTHS AND LIMITATIONS OF THE STUDY

The presented study, "Health Effects of Video Display Terminals (VDTs) in the Workplace", addresses many of the criticisms of studies of VDTs that have been conducted previously. This section describes those strengths in comparison to other studies whose methods have been criticized. The section also comments on how widely these findings can be extended to other Massachusetts VDT workers.

Many VDT studies have been discounted because they lacked a comparison group; this study includes a sizeable control group of non-VDT clerical workers, employed by the same companies and, in many instances working in the same or adjacent rooms. The non-VDT clerical workers are comparable to the VDT users with respect to age, work responsibilities, indoor air environment and other variables that could account for differences in the frequency of symptoms among groups of clerical workers.

Second, other studies have been criticized for bias resulting from only investigating sites where office workers have been reporting adverse health effects from office work. Several NIOSH Health Hazard Evaluations (Smith A B (1982), Smith M J (1983) and Murray (1981)), were initiated by heightened concern about specific symptoms among employees at those locations. The resulting investigations identified health symptoms which had already been reported among the study population. The Massachusetts office workers study used a random sample of companies as sites for

evaluation. The method of choosing randomly among all employers with more than fifty employees, in selected industry groups, tends to prevent selection bias resulting from the inclusion of subjects who are not representative of all VDT and non-VDT users with respect to the frequency of health conditions. Within selected companies, individual study subjects were selected according to the guidelines described previously in this report: (1) all clerical workers were included in the study for sites employing few such workers; (2) for larger sites, the goal was to include no more than 200 workers, with approximately one-third of these workers in positions that do not involve VDT use, one-third in the high VDT use category (seven or more hours per day), and the remaining one-third comprised of those workers who use VDTs between one-half and six hours per day. The particular subset of eligible workers included in the study was determined at random by first selecting floors or departments, and then rooms of workers. Overall, an attempt was made to study approximately 300 subjects in each industry category.

The selection of sites by a random process and the fact that the study's subjects were similar in demographic characteristics to other Massachusetts clerical workers suggests that the study results can be generalized to other members of the group from which the sample was drawn. This means that it would be expected that our results would apply to clerical employees within all Massachusetts industries studied.

Third, many studies have been criticized for a small participation rate among the study population. If few questionnaires are completed and returned in a study, then it is not clear whether those who responded are the same as or different than those who did not respond. If those who have more health complaints are more likely to respond, and if such differential response varies according to daily VDT use, then such response introduces a selection bias into the study, and the results are not characteristic or descriptive of the population as a whole. The final participation rates in this study for the work sites in each industry group were as follows: 100 percent from banking, hospitals and the Commonwealth of Massachusetts; communications: 80 percent; public utilities: 71 percent; and computer and data processing services: 67 percent. The participation rate among individuals was 94 to 99% by site, and 97% overall.

A fourth criticism of VDT studies has been of the tendency to ask leading questions that could result in an increased reporting of symptoms. It should be stressed that this study was presented as an investigation of "The Health and Well-Being of Office Workers," and not as a "VDT Study." A copy of the questionnaire is attached (Appendix III) which shows the wording of questions in a non-leading and non-judgmental manner. Information regarding symptoms is elicited prior to information about the respondent's work. There was no attempt by the study team to lead respondent6s to claim work-

relatedness of any reported symptoms.

Fifth, one NIOSH study has been criticized because it was conducted during heated labor negotiations. Intensified feelings about management's perceived lack of response to union demands could lead to heightened reporting of physical symptoms associated with work. NIOSH was indeed called in because of a large number of health complaints from VDT operators. The timing of their study would lead some to consider their results invalid. Random choice of sites and representative sampling of office workers addresses that potential error.

Sixth, others have noted that in many studies, demographic variables such as age, sex, and educational background have been ignored. In many cases, data from programmers, supervisors, and those with primarily autonomous, challenging and responsible positions have been analyzed together with clerical employees whose work is more routine and who have less control over their job tasks. This error would tend to obscure the health effects that might be present in part of the study population by combining people whose work, VDT use and health outcomes are different. Several investigators (Karasek, 1979; Hunting, 1981) have demonstrated clearly the importance of differentiating between the manner in which VDTs are used and the amount of control the employee has over her/his work. Variables that might separate programmers from data entry clerks, for example, would include: diversity of tasks, flexibility,

control over hours and structure of work, salaried vs. hourly wages, benefits, supervision, machine pacing, machine monitoring, and work breaks. This study prevents this potential error by focusing on a relatively homogeneous group with respect to diversity of job tasks, flexibility and other factors mentioned above. The study also measures the impact of several additional variables on the evaluated outcomes. It was found that age, smoking habit, industry, wearing glasses or contact lenses, and attendance at VDT training classes did not affect the results.

Summarizing the above strengths, the presented study, by its design and analysis, provides new information about the health effects of VDTs on clerical workers. The results from this controlled, objective epidemiological study can be generalized to clerical workers in the following industries: hospitals, banking, computer and data processing services, Commonwealth of Massachusetts and public utilities. The results may also be applicable to other clerical workers in industries with similar job tasks.

There are two limitations of the data. The first limitation concerns the communications industry, SIC code 48. Although 80% of the companies contacted participated, thus describing a major section of the industry as a whole, a major employer refused to participate. Because this employer accounts for an estimated 60% of employees in the communications field, the findings may apply to only a segment of the industry group as a whole.

The second limitation was the absence of data from another industry, insurance, which was originally included in the study protocol. Sample selection and contact by letter, telephone and in person, to company representatives proceeded in a manner similar to that for all other industries. However, only three insurance companies of the seven contacted agreed to participate, resulting in a participation rate of only 43%. Also, in one of the three participating companies, the sample was further restricted to a group chosen by a company official from all employees, including managers, supervisors, programmers, and maintenance personnel. None of the three participating insurance companies represented an employer of 1,000 or more employees. The three companies contacted from that employment size decided not to participate.

Insurance companies gave many reasons for not participating. These reasons included:

> "The company already monitors the office environment on a continuing basis"; "The company is expanding and cannot provide adequate support staff to conduct the study"; "The scope of the questionnaire is too broad"; "The questionnaire would scare employees and create problems which did not really exist".

Whether the study results apply to clerical workers in the insurance industry is not clear.

EDUCATIONAL PROGRAMS

EDUCATIONAL PROGRAMS

There is a need to prepare and educate workers at all levels when new methods and machines are introduced in any work setting. It is well known that people do not accept changes readily and fears arise. With the introduction of computer technology into the office setting, some of the fears commonly expressed by clerical workers include possible job loss with automation, inability to learn computer skills or to keep up with increased expectations of productivity, as well as health hazards that could be associated with the technology.

Although computer manufacturers maintain that VDTs present little or no inherent health or safety risks, many office workers disagree. The literature reviewed for this study and the findings of the present study indicate that untoward health effects reported by operators are associated with VDT use. Such effects include adverse visual and musculoskeletal conditions and headaches as well as symptoms of excessive stress.

It is the belief of educators and scientists that proper education can be an important means to prevent or reduce the health problems associated with office work, and in particular with VDT use. Education aids communication among managers , supervisors and the employees who experience the symptoms. For this reason, the Division of Occupational Hygiene decided to offer educational seminars to the participating industries both as a benefit and as an

incentive to participate.

After the collection of data was completed, all companies who participated in the study were offered at no charge the opportunity to have an educational seminar conducted at the work site on ways to identify office health hazards and prevent untoward health effects among the workers. These seminars were provided under contract by personnel from the Office Technology Education Project (OTEP). Curriculum materials were developed for use by managers, supervisors and clerical workers, with special emphasis on the users of VDTs. The seminars were offered on an optional basis and were adapted to the needs of the individual companies.

The seminar curriculum included information on low or no cost measures to prevent VDT-related problems, information on common health conditions of office workers and prevention of these conditions, the benefits of ergonomic and adaptable office equipment for VDT users, and work practices which reduce discomfort, stress and other adverse health conditions. Educational materials in the form of fact sheets on each of these factors were prepared and distributed at the seminar. The fact sheets were entitled HEALTH EFFECTS OF VDTS and OFFICE HEALTH AND SAFETY IN THE SPOTLIGHT. (Appendices VI and VII).

Fifteen industries including four state agencies participated in the educational seminars. In general, the companies took advantage of these free seminars to educate personnel office staff, managers and supervisors from VDT use areas within their plant. Standard

evaluation forms were distributed and received from persons who attended the seminar. The seminars were highly rated in terms of usefulness and interest by the majority of participants. Several participating companies were redesigning office organization to accomodate VDT use and planned to incorporate some of the ergonomic factors recommended.

The following paragraph is part of the evaluation summary prepared by the OTEP staff:

> One valuable achievement of the educational component is that of simply making employers aware of the toll taken by common office and VDT-related health problems. Because common office ailments do not have immediate or life threatening effects, they are often not taken seriously by those who are not affected. A second important achievement of the educational program was to introduce participating companies and VDT users to the body of knowledge available about proper office ergonomics. Many -- in fact, most -- were simply not aware of the practical and effective guidelines for preventing adverse health effects as VDT use becomes more widespread.

Lack of appropriation precluded a follow-up visit to measure the effectiveness of the educational seminars. Evaluation of the impact of this component of the study would be beneficial and future analyses should include the effect of education on changes in the workplace and changes in the frequency of symptoms. Such evaluation would include an assessment of the VDT workstations and health symptoms reported by the operator before and after the seminar to determine the effects of education.

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A P P E N D I C E S

APPENDIX I

Leonard D. Pagnotto, C.I.H.
Director

The Commonwealth of Massachusetts

Executive Office of Labor

Department of Labor and Industries
Division of Occupational Hygiene
1001 Watertown Street
West Newton 02165

In Your Reply
Refer to File

The Massachusetts Division of Occupational Hygiene at the request of the Legislature is undertaking a survey of occupational factors in the office environment. The survey will include the administration of a health questionnaire and industrial hygiene measurements.se of the survey is to identify environmental factors which tend to affect the health conditions of office workers. Our agency is also offering as a follow-up service an educational seminar, free of charge, tailored to the specific needs of your organization.

The ultimate goal of the program is to encourage and develop inexpensive and feasible solutions to improve the office environment and increase the efficiency of office operations. It is believed that through education, many of the concerns of office workers can be directly addressed and alleviated.

Sites chosen for the survey have been selected through a non-biased representative sampling method. The names of participating companies or subjects surveyed will not be identified.

Your company has been selected at random from your industry group to participate in this survey. As a participant, your name, location and the identity of any persons surveyed will remain strictly confidential. A copy of the final report of the survey data and analysis will be available to you.

A member of our staff will be calling you within a few days to confirm the date scheduled for the survey. Your office is tentatively scheduled for

Thank you for your assistance with this survey. We look forward to being of service to you. If there is any question, please call me at 969-7177.

Very truly yours,

Leonard D. Pagnotto, C.I.H.
Director

APPENDIX II

Leonard D. Pagnotto, C.I.H.
Director

The Commonwealth of Massachusetts

Executive Office of Labor

Department of Labor and Industries
Division of Occupational Hygiene
1001 Watertown Street
West Newton 02165

In Your Reply
Refer to File

As a participant in the Office Environmental Occupational Study, we are pleased to offer your company an educational seminar entitled "How to Prevent Office Health Hazards". The seminar is being offered at no charge to all study participants by the Office Technology Education Project (OTEP), under the sponsorship of the Massachusetts Division of Occupational Hygiene.

It is widely recognized that office health hazards can be easily prevented through proper office and job design. In particular, when video display terminals (VDTs) are introduced, needed adaptations in office and job design are often not made. The result can be increased health complaints, higher absenteeism, and lower productivity. Office personnel, from clerical staff to managers, are often not aware of the necessary changes that can enhance use of automated equipment.

The seminar we offer is suitable for all who are interested -- managers, users, those who purchase the equipment, etc. Our main focus is on inexpensive, practical measures to prevent unnecessary office health problems and make the most of new automated systems. We think you will find it worthwhile to set aside an hour for your employees to attend this program.

We will be contacting you shortly to schedule a date for the seminar. If you have any questions, please leave a message at the Division of Occupational Hygiene office (969-7177) and we will return your call at the earliest possible time.

Sincerely,

Deborah Katz, Co-Director
Office Technology
Education Project

APPENDIX III

Leonard D. Pagnotto, C.I.H.
Director

The Commonwealth of Massachusetts

Executive Office of Labor

Department of Labor and Industries
Division of Occupational Hygiene
1001 Watertown Street
West Newton 02165

In Your Reply
Refer to File

February, 1985

Dear Office Worker:

This survey is part of research project on the health of office workers in different types of office settings. We ask questions about your health and well-being, the type of work you do, and your opinions and feelings about your job. The purpose of the study is to obtain information that you can help to improve the working conditions of people like yourself.

There are no right or wrong answers to these questions, since people and jobs differ. Your answers are totally confidential and will be seen only by the research staff. All participants in the study and their places of employment will remain anonymous. Please do not write in your name or place of work.

Most questions can be answered either by circling a number 1 2 3 4, a letter A B C D, word or phrase or by placing a check in the appropriate column. If you do not find the exact answer, choose the closest one. Don't spend too long on any question. For some questions you will fill in the blank_____.

We are very grateful for your assistance.

Sincerely,

Leonard D. Pagnotto, C.I.H.
Director

Questionnaire number_____ /_/_/_/_/
_____ /_/_/_/

OFFICE WORKERS QUESTIONNAIRE

do not write in this column

GENERAL INFORMATION

1. What is your age?_____ /_/_/ 8,9

2. What is your sex? F_____ M_____ /_/ 10

3. Please circle the ethnic group to which you belong.

Hispanic Asian Black White Other /_/ 11

4. Please circle the highest grade in school that you have completed.

Elementary school Junior High (8th or 9th grade) High school

Junior college (or 1-2 years of college) College graduate Graduate school

Other_____ /_/ 12

HEALTH INFORMATION

5. Do you smoke cigarettes? Yes No /_/ 13

If you smoke cigarettes, how many cigarettes do you smoke each day?_____ /_/_/ 14,15

6. Please circle the answer that best describes the number of days you have had a cold or sore throat during the past two (2) months.

No cold or sore throat during past 2 months. 2-5 days /_/ 16

8-12 days 20 days or more

7. Do you wear either eyeglasses or contact lenses at work? Yes No /_/ 17

If you wear glasses or contacts, please circle the type you usually wear.

Glasses (not bifocals) Bifocals or trifocals

Contacts (not bifocals) Bifocals contacts /_/ 18

8. During the past 6 months, has your vision changed, as far as you know?

No change Vision is better Vision is worse /_/ 19

9. What year did you last go to an eye doctor to have your eyes or vision checked?_____ /_/_/ 20,21

Questionnaire number_____

MEANINGS: Almost always: Four or more times each week
Frequently: About one time each week
Occasionally: About one time each month
Not at all: Not at all during the past two months

do not write in this column

10. Please circle the answer that best describes how often during the past two months that you have had a headache according to the above meanings.

Almost Always Frequently Occasionally Not at all /_/ 22

11. If you have had headaches, please circle the one answer which best describes where the headaches usually seem to be located:

Forehead Back of the head Temples or sides of head

Behind the eyes Other (please specify)_____ /_/ 23

12. Please check the answer that best describes how often during the past two months that you have experienced the following conditions, according to the meanings above:

CONDITIONS	ALMOST ALWAYS	FREQUENTLY	OCCASIONALLY	NOT AT ALL	
A Eyestrain or sore eyes	_____	_____	_____	_____	/_/ 24
B Blurred vision	_____	_____	_____	_____	/_/ 25
C Tearing or itching eyes	_____	_____	_____	_____	/_/ 26
D Burning or irritated eyes	_____	_____	_____	_____	/_/ 27
E Redness of eyes	_____	_____	_____	_____	/_/ 28

IF YOU CHECKED NOT AT ALL FOR A-E ABOVE, PLEASE SKIP TO QUESTION 18.

13. Have any of the conditions listed in question 12 been severe enough to make you stop working on a particular task or take a break? Yes No /_/ 29

14. Have any of the conditions listed in question 12 been severe enough to prevent you from sewing, reading or other similar activities when you go home from work? Yes No /_/ 30

15. Have any of the conditions listed in question 12 been severe enough to require treatment by a doctor or nurse? Yes No /_/ 31

16. Have any of the conditions listed in question 12 been severe enough to cause you to miss work during the past two (2) months? Yes No /_/ 32

17. How many days of work have you missed during the past two (2) months because of any of the conditions checked in question 12.
_____ /_/_/33,34

18. How many days of work have you missed during the past two (2) months in total, for any reason other than vacation?_____ /_/_/35,36

Questionnaire number_____

19. Please check the answer that best describes how often during the past two months that you have experienced the following conditions according to the meanings described below:

MEANINGS: Almost always: Four or more times each week
Frequently: About one time each week
Occasionally: About one time each month
Not at all: Not at all during the past two months

CONDITIONS	Almost always	Fre-quently	Occasion-ally	Not at all	
A. Neck pain, stiffness or soreness	_____	_____	_____	_____	/_/ 37
B. Shoulder pain, stiffness or soreness	_____	_____	_____	_____	/_/ 38
C. Lower back pain	_____	_____	_____	_____	/_/ 39
D. Upper back pain	_____	_____	_____	_____	/_/ 40
E. Arm pain, stiffness or soreness	_____	_____	_____	_____	/_/ 41
F. Pain in hands, fingers or wrist	_____	_____	_____	_____	/_/ 42
G. Numbness or tingling in hands	_____	_____	_____	_____	/_/ 43

IF YOU CHECKED NO TO ALL OF THE CONDITIONS LISTED IN QUESTION 19 PLEASE SKIP TO TO QUESTION 25.

20. Have any of the conditions listed in question 19 been severe enough to require you to take aspirin or other medicine during the past two months? Yes No /_/ 44

21. If you answered yes to question 20, please circle the body part(s) for the condition(s) that have been severe enough for you to take aspirin or other medicine:

Neck Shoulder Lower back Upper back /_/_/_/_/45-48

Arm Hands, fingers or wrist Numbness or tingling in hands

22. Have any of the conditions listed in question 19 been severe enough to cause you to miss work during the past two months? Yes No /_/ 49

23. If yes, please circle the body part(s) for the condition(s) that have been severe enough for you to miss work.

Neck Shoulder Lower back Upper back /_/_/_/_/50-53

Arm Hands, fingers or wrist Numbness or tingling in hands

24. How many days of work have you missed during the past two months because of any of the conditions listed in question 19?_____ /_/_/54,55

Questionnaire number_____
_____

25. How often do you become tired in a very short period of time? Please circle the answer that best describes how often.

Often Sometimes Rarely Never /_/ 56

26. Do you ever have difficulty breathing when you are not exercising?

Often Sometimes Rarely Never /_/ 57

27. Do you ever have pains, jabs, or a tight feeling in your chest?

Often Sometimes Rarely Never /_/ 58

28. Do you ever have sweaty hands which feel damp and clammy?

Often Sometimes Rarely Never /_/ 59

29. Do you ever feel nervous, fidgety, or tense?

Often Sometimes Rarely Never /_/ 60

30. Do you ever notice your heart pounding or racing?

Often Sometimes Rarely Never /_/ 61

31. Do you ever have a poor appetite?

Often Sometimes Rarely Never /_/ 62

32. Do you ever have difficulty getting to sleep?

Often Sometimes Rarely Never /_/ 63

33. Do you ever have difficulty staying asleep?

Often Sometimes Rarely Never /_/ 64

34. Do you take any medicine to calm yourself or help you sleep?

Often Sometimes Rarely Never /_/ 65

35. How many cups of coffee, tea or cola (diet or regular) do you drink on a typical day? Please specify: coffee___ tea___ cola___ /_/_/_/ 66-68

Questionnaire number_____

36. Have you ever been told by a doctor or nurse that you have any of the following conditions? Please circle yes or no for each condition. If yes, please write when you were first told that you had the condition(s). In the last column put a check after those condition(s) you still have and for which you are still being treated or taking medicine.

CONDITION	PLEASE CIRCLE		DATE DIAGNOSED	( ) STILL UNDER TREATMENT	
High blood pressure	Yes	No	_____	_____	/_/_/_/ 69-71
Heart disease	Yes	No	_____	_____	/_/_/_/ 72-74
Stomach or duodenal ulcer	Yes	No	_____	_____	/_/_/_/ 75-77
Arthritis	Yes	No	_____	_____	/_/_/_/ 78-80
Migraine headache	Yes	No	_____	_____	/_/_/_/ 81-83
Hayfever or allergies	Yes	No	_____	_____	/_/_/_/ 84-86
Bronchitis or emphysema	Yes	No	_____	_____	/_/_/_/ 87-89
Asthma	Yes	No	_____	_____	/_/_/_/ 90-92
Back or neck injury	Yes	No	_____	_____	/_/_/_/ 93-95
Arm, shoulder or hand injury	Yes	No	_____	_____	/_/_/_/ 96-98
Other _____ (please specify)	Yes	No	_____	_____	/_/_/_/ 99-101

NATURE OF WORK ACTIVITIES

37. What is your present job title/classification?_____ /_/ 102

38. How many years have you been employed in your present job?_____ /_/_/ 103,104

39. How many years have you been employed with this company in any job_____/_/_/ 105,106

40. How many years have you been employed as an office worker?_____ /_/_/ 107,108

41. How many hours per day do you work at your present job?_____ /_/ 109

42. How many days per week do you work at your present job?_____ /_/ 110

43. How many times each day do you usually leave your desk/workspace?_____ /_/ 111

44. What is the longest time you usually work without a break?_____ /_/ 112

Questionnaire number_____

45. Which answer best describes how often you are required to work overtime.

Almost always Often Sometimes Not at all /_/ 113

46. I like the work I am doing.

Almost always Often Sometimes Not at all /_/ 114

47. Please circle the number which best describes the number of hours each day that you usually work on each of the following machines?

	Time in hours per day									
Typewriter	0	1/2-1	2	3	4	5	6	7	8+	/_/ 115
Switchboard	0	1/2-1	2	3	4	5	6	7	8+	/_/ 116
Keyboard machine with visual display screen (VDT, CRT, word processor or computer terminal)	0	1/2-1	2	3	4	5	6	7	8+	/_/ 117
Copier	0	1/2-1	2	3	4	5	6	7	8+	/_/ 118
Adding machine	0	1/2-1	2	3	4	5	6	7	8+	/_/ 119
Other desk work	0	1/2-1	2	3	4	5	6	7	8+	/_/ 120

48. IF YOU WORK ON A KEYBOARD MACHINE WITH A VISUAL DISPLAY SCREEN, PLEASE ANSWER THE FOLLOWING QUESTIONS. IF YOU DO NOT USE THIS MACHINE, GO TO QUESTION 53.

a. For how many months or years have you been working on a keyboard machine with a visual display screen? months_____ years_____ /_/_/121,122

b. Please check the ONE answer that best describes the type of work you usually do on the keyboard machine.

_____Enter numbers or words into the machine /_/123

_____Read (but not enter) numbers or words from the machine /_/124

_____Enter and read numbers or words /_/125

_____Word processing /_/126

_____Checking information in the computer against written records /_/127

_____Program or edit computer files or data /_/128

_____Other (please specify)_____ /_/129

c. Have you attended a training class to teach you how to use a keyboard machine with visual display screen? Yes No /_/130

Questionnaire number_____

FOR QUESTIONS 49 - 52, PLEASE CIRCLE THE ONE ANSWER THAT BEST DESCRIBES HOW MUCH YOU AGREE OR DISAGREE WITH THE STATEMENT.

49. I can control the pace of my work when I work with our computer system or automated equipment.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 131

50. The computer system or automated equipment checks the speed or accuracy of my work for my supervisor.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 132

51. My supervisor regularly reports to me on the speed and accuracy of my work.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 133

52. The computer system or automated equipment rarely breaks down or stops.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 134

---

53. Please check the answer that <u>best</u> describes how steady your work is:

_____Regular and steady _____Frequent layoffs

_____Seasonal _____Both seasonal and frequent layoffs

_____Other (please specify)_____

/_/ 135

54. Please circle the answer that best describes how often, <u>during the past year</u>, you were in a situation where you faced job loss or layoff?

Never	Faced the possibility once	Faced the possibility more than once	Constantly	Actually layed off	/_/ 136

55. How satisfied are you with your job?

Not at all	Not too	Somewhat	Very	/_/ 137

56. Would you advise a friend to take this job?

Advise against	Have doubts about it	Strongly recommend	/_/ 138

Questionnaire number_____

57. Would you take this job again?

Take without hesitation Have second thoughts Definitely not /_/ 139

58. How likely is it that you will find a new job in the next year?

Very likely Somewhat Not at all /_/ 140

59. Is this job what you thought it would be when you were hired?

Very much Somewhat Not very much /_/ 141

FOR QUESTIONS 60 TO 82, PLEASE CIRCLE THE ONE ANSWER THAT BEST DESCRIBES HOW MUCH YOU AGREE OR DISAGREE WITH THE STATEMENT.

60. My job requires that I learn new things.

Strongly Disagree Disagree Agree Strongly Agree /_/ 142

61. My job requires a lot of repetitive work.

Strongly Disagree Disagree Agree Strongly Agree /_/ 143

62. My job requires me to be creative.

Strongly Disagree Disagree Agree Strongly Agree /_/ 144

63. My job allows me to make a lot of decisions on my own.

Strongly Disagree Disagree Agree Strongly Agree /_/ 145

64. My job requires a high level of skill.

Strongly Disagree Disagree Agree Strongly Agree /_/ 146

65. On my job, I have very little freedom to decide how I do my work.

Strongly Disagree Disagree Agree Strongly Agree /_/ 147

66. I get to do a variety of diffrent things on my job.

Strongly Disagree Disagree Agree Strongly Agree /_/ 148

Questionnaire number_____

67. I have a lot to say about what happens on my job.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 149

68. I have an opportunity to develop my own special abilities.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 150

69. My job requires working very fast.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 151

70. My job requires working very hard.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 152

71. I am not asked to do an excessive amount of work.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 153

72. I have enough time to get the job done.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 154

73. I am free from conflicting demands others make.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 155

74. My job requires long periods of intense concentration on the task.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 156

75. My tasks are often interrupted before they can be completed, requiring attention at a later time.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 157

76. My job is very hectic.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 158

Questionnaire number_____

77. I am often required to work for long periods with my body in physically awkward positions.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 159

78. I am required to work for long periods with my head or arms in physically awkward positions.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 160

79. Waiting on work from other people or departments often slows me down on my job.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 161

80. My job security is good.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 162

81. My prospects for career development and promotion are good.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 163

82. In five years, my skills will still be valuable.

Strongly Disagree	Disagree	Agree	Strongly Agree	/_/ 164

83. For women only: Do you commonly experience headaches before your menstrual periods? Yes No /_/ 165

Do you commonly experience backaches before your menstrual periods? Yes No /_/ 166

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.
COMMENTS:_____

APPENDIX IV

MASSACHUSETTS DIVISION OF OCCUPATIONAL HYGIENE

OFFICE WORKERS STUDY

FIELD DATA COLLECTION SHEET

Date_____ Time_____ Company Code_____

Location (floor and room)_____

Questionnaires distributed: From_____ To_____

Total # of Q's_____ Total # of people in the room_____

# of VDT's_____ # of people at desk w/VDT_____

# of ashtrays at occupied desks_____

AIR QUALITY:	INSTRUMENT	NOTES
Temperature_____	_____	_____
Humidity_____	_____	_____
Carbon Dioxide_____	_____	_____
		_____
		_____
		_____

Is map attached? Yes No

Initials_____

COMMENTS

By Workers?_____

_____

Anyone Refuse? Why? (Age, Ethnicity, Sex)_____

_____

Other Observations:_____

_____

_____

_____

_____

_____

_____

APPENDIX V

Number_____

FIELD DATA COLLECTION - RADIATION

Date_____Time_____

Company_____ Location_____Code____

Number of VDTs of this kind_____ Number of operators on this VDT_____

VDT Manufacturer_____ Model number_____ S/N_____

Approximate use/day (hours/day)_____

		Range	Comments (scale change, distance to 0)
Victoreen:	Background	_____mR/hr	_____
440/RF/C	Front	_____mR/hr	_____
1-2 inches	Left	_____mR/hr	_____
low range	Right	_____mR/hr	_____
13 seconds	Top	_____mR/hr	_____
	Back	_____mR/hr	_____
	Operator	_____mR/hr	_____

		X	Y	Z	Comments (*antenna/range change)
EFS-2	Background	_____V/m			_____
long antenna	Front	_____V/m	_____V/m	_____V/m	_____
CW switch	Left	_____V/m	_____V/m	_____V/m	_____
1-2 inches	Right	_____V/m	_____V/m	_____V/m	_____
	Top	_____V/m	_____V/m	_____V/m	_____
	Back	_____V/m	_____V/m	_____V/m	_____
	Operator	_____V/m	_____V/m	_____V/m	_____
(Fluorescent Lights)		_____V/m	_____V/m	_____V/m	_____

		Ave	Max	Comments
RAHAM	Background	_____mW/cm^2	_____mW/cm^2	_____
max sensi	Front	_____mW/cm^2	_____mW/cm^2	_____
tivity	Left	_____mW/cm^2	_____mW/cm^2	_____
	Right	_____mW/cm^2	_____mW/cm^2	_____
	Top	_____mW/cm^2	_____mW/cm^2	_____
	Back	_____mW/cm^2	_____mW/cm^2	_____
	Operator	_____mW/cm^2	_____mW/cm^2	_____

Radiometer	Far UV (270 nm)_____	watts/cm^2	_____
	Near UV (355 nm)_____	watts/cm^2	_____
	Blue light (450 nm)_____	watts/cm^2	_____
Luminance unhooded	_____	footlamberts range	_____
Luminance hooded	_____	footlamberts range	_____

FIELD DATA COLLECTION _ RADIATION page 2 Number_____

		Ave	Peak Hold	Distance to 0	Comments
HI 3002	Background	_____(FSU)^2	_____(FSU)^2		
Black Band	Front	_____(FSU)^2	_____(FSU)^2		
H Field	Left	_____(FSU)^2	_____(FSU)^2		
	Right	_____(FSU)^2	_____(FSU)^2		
	Top	_____(FSU)^2	_____(FSU)^2		
	Back	_____(FSU)^2	_____(FSU)^2		
	Operator	_____(FSU)^2	_____(FSU)^2		
HI 3002	Background	_____(FSU)^2	_____(FSU)^2		
Green Band	Front	_____(FSU)^2	_____(FSU)^2		
H Field	Left	_____(FSU)^2	_____(FSU)^2		
	Right	_____(FSU)^2	_____(FSU)^2		
	Top	_____(FSU)^2	_____(FSU)^2		
	Back	_____(FSU)^2	_____(FSU)^2		
	Operator	_____(FSU)^2	_____(FSU)^2		

GE Light Meter Keyboard_____foot candles

Paper_____foot candles

Operator_____foot candles

APPENDIX VI

Office Health and Safety In the Spotlight

Occupational safety and health in the office is not a new concept. But it probably seems like suddenly everybody's talking about office health and safety. What has changed?

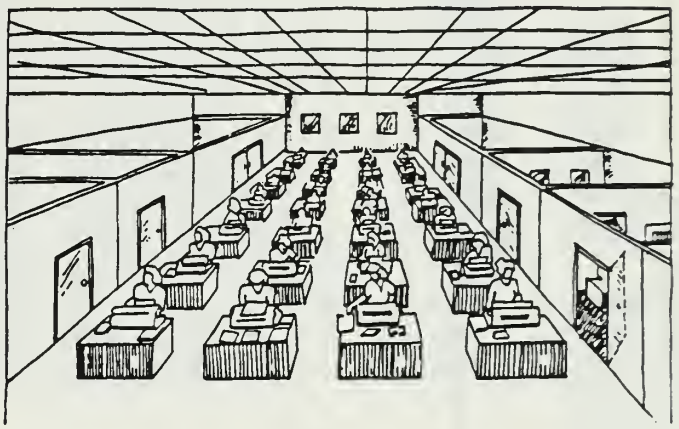
• Women — who account for over 80% of clerical workers — are in the workforce to stay. Today, more than half of all women work outside of the home. A full 35% share a single occupation — clerical work. Thus, for working women, any ill-effects of office work have a far-reaching impact.

• Clerical work is the fastest growing occupation of the decade, according to the U.S. Dept. of Labor. That means more and more men and women will find themselves working behind a desk. Thus, for all of society office health and safety has taken on added significance.

• The biggest change of all is the appearance of the video display terminal (VDT). VDTs mark what is widely called a "Technological Revolution" in the office. They are changing how offices look and how work is done. The new technology has the potential to enhance the quality of office jobs and open up new opportunities. But thus far, VDTs have given rise to a dramatic increase in reports of health problems among clerical workers.

Of course, common office ailments — such as eyestrain, muscle pain, headache, and stress — existed long before VDTs were introduced. They may be caused by hazards related to OFFICE DESIGN (the physical environment and equipment, such as poor ventilation or improper lighting) and JOB DESIGN (what you do and how you do it, for instance lack of promotional opportunities or unrealistic expectations). Fitting the job environment and tasks to the person — called the science of ERGONOMICS — can prevent adverse health effects associated with a diversity of occupations.

Yet VDTs are increasing health problems for many office workers. The reason: as VDTs are brought in, needed adaptations in both office and job design are often overlooked.



Prevention Pays

New technologies have propelled the office of today into a dynamic state of flux. There's no better time to start making improvements. Studies and actual experience increasingly show that a commitment to an appropriate office environment and work practices more than pays for itself. And the benefits can be far-reaching:

- better employee health
- enhanced employee satisfaction
- lower rates of absenteeism and turnover
- increased productivity
- reduced chance of legal liability for job-related illness
- increased effectiveness of new office systems.

An Overview Inside . . .

Solutions to office hazards are often simple and practical. However, no two offices are alike, and a wide variety of symptoms can result from a single hazard or combination of hazards. Use the inside chart to gain an overview of office health concerns and preventive measures. See *Health Effects of VDTs* for a focus on automation.

Common Office Hazards . . . and How To Avoid Them

Hazard	Effect	Prevention
Office Environment		
Poor Air Quality and Ventilation • not enough fresh air, known as "tight building syndrome" • harmful substances circulating in air such as: fumes from office machines, germs from air conditioning system, cigarette smoke, asbestos from insulation or building materials, fumes from nearby factories or labs • temperature too hot or too cold	Headache and fatigue from lack of fresh air. Effects of fumes vary: include irritation to eyes, nose and throat; flu, colds, and viruses; lung disease.	• ventilation systems designed to provide adequate supply of fresh air • ventilation systems cleaned and inspected regularly • office machines that can emit dangerous fumes well-serviced and maintained; installed in separate area where no general work is done and good ventilation provided • individual area control over flow of air and temperature.
Lighting • too bright or too dark • glare from lights and highly reflective equipment and surfaces • reading small figures or unclear print	Short-term eyestrain, discomfort and difficulty focusing. Longterm effects not yet known. Headache, fatigue, stress, and muscle strain may also result.	• adjustable lighting, including both general (overhead) and individual lamps for particular tasks • non-glare desk tops and wall paint • furniture arranged to avoid glare from windows and bright lights • printed copy of reasonable quality
Noise • high levels of noise like those from keypunches and computer printers • lower levels of noise such as hum from VDTs and fluorescent lights	Stress and its effects result from even low noise exposures. Possible hearing loss can occur from constant exposure to very loud office machinery.	• noisy equipment located in separate area not used for general work • noise-reducing covers and pads on printers, typewriters, etc. • soundproof environment: carpeting, sound-absorbing partitions between individual work areas.
Unsafe Conditions • slipping on wet or polished floor • tripping on furniture, mats, cords • sharp tools such as paper cutters, staplers • lifting heavy cartons or machinery	Muscle strain, broken bones, cuts, abrasions, and other injuries.	• proper cleaning and maintenance of office environment • proper use and storage of sharp tools • no requirements to lift heavy loads without assistance if needed.
Fire • no sprinkler system • lack of fire safety plan • plastic materials that emit toxic smoke when burning • clutter of papers, plastics, and other flammable materials • "open" office (few walls) without means to contain a fire; fire doors propped open	Burns, smoke inhalation, and exposure to poisonous chemical fumes.	• alarms and sprinkler system • fire plan and drills • reduce clutter of flammable materials, especially plastics • furnish office with flame retardent items • keep fire doors closed

Office Equipment

Photocopiers • can emit ozone, a hazardous gas • may expose user to excessive noise and light • toners and solvents can contain toxic substances although exposure should not occur in normal use • chemically coated papers	Ozone causes eye, nose, and throat irritation and may lead to lung disease. Noise can contribute to hearing loss or stress. Effects of bright light unknown. Toners and solvents may be carcinogenic. Allergic skin reactions from papers.	• machines installed in separate areas where general work not carried out and excellent ventilation is provided • regular maintenance only by trained service personnel • use gloves if necessary with some papers
Furniture • chair uncomfortable, with no back support; not easily adjustable; unsteady base; no casters for easy reaching and movement • desk too high • phone not an easy reach from typewriter or VDT	Aches in neck, back, legs, arms or hands from lack of proper support. Accidents from awkward reaching.	• easily adjustable chair height and backrest position • desk and chair height positioned so that arms and thighs approximately parallel to floor and feet flat on floor when typing • foot rest for shorter people • equipment sensibly arranged
Video Display Terminals (VDTs) • glare from VDT screen; overhead lighting too bright • desk and chair not adjustable for proper keyboard and screen height • hums and high frequency sounds; noisy printers • constant movement of fingers while keying • radiation or other reproductive hazard (not yet known) • nature of work done on VDTs often more repetitive and monotonous • monitoring and pacing by machine	Common office health problems — stress, eyestrain, neck and back strain, inflammation of tendons in hands — made worse. Longterm effects of eyestrain unknown. Headache, stress, possible hearing loss from loud printers. Hazard, if any, to pregnant women not yet known.	• moderate overhead lighting and individual task lamps to prevent glare and improve contrast of screen • detachable keyboard and desks with proper levels for keyboard and screen • easily adjustable chair • printers in separate area or equipped with noise shield • non-VDT jobs for pregnant women who choose to transfer • varied work on and off VDT • rest breaks • no machine monitoring of individuals (See OTEP VDT Fact Sheet for more details.)

Work Content

Stressors • repetitive, demanding work • rapid work pacing • little control • strict supervision • discrimination or harassment • lack of promotional opportunity/low pay • muscle, eye or mental fatigue • noise; crowding • juggling home and work responsibilities	Recurring stress can produce insomnia, headaches, backaches, stomach ailments, irritability, exhaustion, and many other symptoms; also can increase sensitivity to fumes or chance of accidents. Over the years, stress can lead to ulcers, high blood pressure, and coronary heart disease.	• more control over the kind and pace of work • rest breaks • effective grievance procedures • fair pay and respect; satisfying work responsibilities • improvements in office environment • relief from burdens of dual role at work and home (for example, good day care, flexible hours)

Clerical Work Is Stressful

Common office ailments may be bothersome, but are they serious? Yes. Take stress for example.

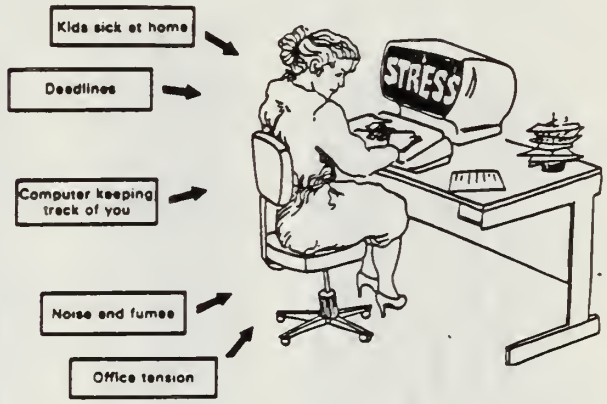
Stress is perhaps the most serious health problem commonly experienced by clerical workers. According to the Framingham, MA Heart Study, female clerical workers experience coronary heart disease about twice as often as other working women. Heart disease, the major cause of death in the U.S., is known to be related to stress.

Stress refers to a series of physical changes when the body gears up to meet a challenge. Your heart beats faster, you break into a sweat, breathe more rapidly, and your body releases chemicals which give you quick energy. These changes work well when they give you the extra drive to get on top of a situation and then return to a relaxed state. However, when someone is under stress day in and day out, things begin to backfire, and the stress reaction can begin to cause disease.

Some of the symptoms of stress are: headache, back or neck ache, stomach problems, trouble sleeping, constant tiredness, loss or gain in appetite, frequent colds or flus, sexual or family problems. You may often feel anxious, depressed, irritable, bored, helpless or worthless. Some may turn more to cigarettes, alcohol, or drugs. These symptoms are not signs of personal weakness: they are the effects of the body's response to stress.

These early signs can develop into serious disease such as: high blood pressure, coronary heart disease, ulcers, diabetes, and greater vulnerability to infection and illness.

One government study (NIOSH) of 22,000 workers in 130 occupations found that clerical workers suffered the second highest rate of stress-related disease. Why is clerical work so stressful? Researchers have looked to job design for the answer. One key to a stressful job is a high level of demands combined with little control over how and when the work is done. Research cites additional aspects of clerical work which are especially stressful, including low pay, little respect, isolation from coworkers, unrealistic demands, monotonous work, and the discrimination experienced by women.



A Five-Point Program For Healthier Jobs

Preventing stress and other common office health problems improves the overall quality and attractiveness of clerical jobs. Everyone benefits. The first steps are to:

RECOGNIZE the significance of office health hazards and the benefits of prevention

INVOLVE personnel at all levels, especially those who work in the office themselves, in identifying hazards and solutions

ASSESS improvements both in terms of improved employee health and satisfaction and longterm benefits to the company

ADAPT the office environment and work practices to avoid identified health problems and prevent possible longterm effects

MINIMIZE ill-health effects, especially of stress, through exercise, good diet, and relaxation while working towards changes in the office.

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Health Effects of VDTs

The promise of new office technologies is far-reaching, and offices everywhere are preparing for the automated future. But along with the benefits of any new technology come new questions and concerns. The challenge in the coming decade — when VDT use is expected to more than quadruple — will be to avoid any negative effects and maximize the potential benefits. To this end, VDT-related health concerns must be addressed.

In recent years, much attention has focused on health and safety in the automated office and hundreds of studies have been conducted throughout the U.S., Canada, Europe and Japan to investigate the complaints of VDT users. Several respected government research bodies have issued reports summarizing the many studies completed to date (see references). These reports verify what many office workers themselves have been saying: traditional health problems of office work may increase with VDT use. Fortunately, research has also found that health problems are largely preventable through a proper workstation and a well-designed job. These findings are summarized below.

Visual Difficulties

In the *National Institute of Occupational Safety and Health* (NIOSH) report summarizing research on VDTs the author notes,

> studies indicate that VDT operators, as a group, suffer from a high incidence of visual disturbances, including visual fatigue, visual irritation, and headaches.

In addition, researchers have found that visual difficulty experienced by VDT users tends to persist longer than that of other office workers.

Why are VDTs harder on the eye? Researchers explain that the continuously refreshed images make difficult demands on the visual process, that glare contributes to visual stress, and that poor contrast often results from improper lighting and low quality glare screens. The video screen may also not be at a comfortable viewing distance, especially for eyeglass wearers. A member of the *National Research Council* (NRC) panel investigating VDTs summarizes, "I have never seen a VDT that was nearly as legible as the ordinary pieces of typewritten paper or copied reports that circulate in our paper world."

Musculoskeletal Pain

NIOSH reports that,

> most types of VDT work generally produce more muscular complaints than other types of traditional office work . . . . This is probably due to the increased postural demands imposed by the viewing requirements of the VDT. The musculoskeletal complaints are of a diverse nature, affecting the neck, shoulders, back, arms, hands and fingers, possibly demonstrating a systemic influence.

Muscle strain increases for VDT users largely because they must be positioned correctly for use of printed documents, the keyboard and the video screen; without proper furniture one of these is often at an improper height or distance. Also, VDT users sometimes work long, uninterrupted periods on the terminal; lack of movement strains muscles and causes fatigue, a condition called "static load."

A recent report for the federal *Office of Technology Assessment* (OTA) explains that musculoskeletal problems can result from both faulty equipment design and faulty job design.

> One of the most consistent results of research on musculoskeletal problems has been the recognition of the importance of the type of task performed. Jobs which are highly repetitive and those involving constrained positions are associated with higher incidence rates of almost all musculoskeletal problems.

Stress

According to the OTA report,

> A number of studies have clearly indicated that VDT tasks with certain characteristics are more stressful than both non-VDT and other types of work. The most frequently mentioned variables were monotony and boredom, monitoring, piecework, loss of control over work pace, technical problems or interruptions and production quotas.

VDTs change jobs in both planned and unplanned ways. For instance, supervisors' expectations are often shaped by vendor promises about the new equipment. The result may be unrealistic expectations and, thus, an unnecessary increase in user stress. These expectations, in some cases, are formalized into production quotas, where employees' keystrokes and errors are measured, and wages and promotions determined by their speed on the VDT.

The NRC states in its 1983 report,

> VDTs, like any other work technology, can be used properly or improperly, and VDT work can be organized so that it reduces stress and increases productivity or increases stress and reduces productivity.

Of course, common office ailments — such as eyestrain, muscle pain, headache and stress — existed long before VDTs were introduced. The concern is that VDTs have increased the incidence of these health problems, though they can be largely prevented through a proper workstation and a well-designed job. One new concern has also arisen with the introduction of VDTs: that of a radiation hazard. Unlike the health problems discussed above, there is little agreement whether radiation presents a hazard to VDT users.

Radiation Hazard

In the last five years over twenty "clusters" of pregnancy problems among VDT users have been reported in the U.S. and Canada. Concern has focused on possible VDT emissions of two forms of radiation: ionizing and non-ionizing. *Food and Drug Administration* (FDA) studies in 1981 found some older VDT models in use between 1975 and 1980 emitted levels of ionizing radiation (x-rays) which exceeded protective standards for pregnant women. After this study, design modifications were made, and new models have not been found to exceed emission standards. Emissions also occurred in tests of seriously malfunctioning terminals; proper maintenance should prevent this hazard.

Non-ionizing radiation includes infrared, ultraviolet, and visible light, radiofrequency, and other forms. Concern centers around two forms: very low frequency (VLF) and extra low frequency (ELF). Controversy exists among researchers: A 1984 *Congressional Research Service* White Paper on VDT hazards concluded it is "premature . . . . to implicate non-ionizing radiation in VDT-related health disorders." Yet, a 1983 *Canadian Centre for Occupational Health and Safety* Study notes that non-ionizing radiation similar to that emitted by VDTs can damage blood cells and produce genetic damage. *The American Conference of Governmental Industrial Hygienists* recommends that, "All radiofrequency radiation exposures should be kept as low as reasonable given the current state of knowledge on human effects . . . " With so little known, many agree that more research is needed on effects of ELF and VLF emissions from VDTS.

The Good News: Prevention

Users, employers, and experts alike agree: health problems experienced by VDT users can be prevented through proper adjustment of the physical environment (office design) and the job itself (job content). The benefits of making improvements can be far-reaching: better employee health and enhanced employee satisfaction (and thus lower absenteeism and turnover), increased productivity, reduced legal liability, and increased effectiveness of new office systems.

Office Design

Purchasing the VDT is only half the job; the other half is remodelling the work area so it is suited to VDT use. The diagram on page 5 points out many features of a VDT work area which may affect health. The guidelines in this diagram will help lessen many of the health problems which are related to VDT use. The user, of course, is the best judge of what feels comfortable, and this diagram should only serve as a guide. The key is adjustability.

Job Design

VDTs are part of an overall process of change resulting from automation. Automation not only changes the way offices look and sound, it changes the content of office workers' jobs. Even a model VDT workstation will not prevent health problems if automated jobs become more stressful.

Practices such as the following help ensure that job quality does not decline when VDTs are used: • rest breaks every two hours for general VDT work or every hour for more demanding VDT work; • a limit of four hours work on the VDT each workday; • retention of jobs with varied duties; • thorough employee training to allow for confident, efficient use of new equipment; • supervisor education so they have reasonable expectations of VDT users; • updated job descriptions and wage increases for those using additional skills on automated equipment • avoidance of individual monitoring of work performance; • sufficient equipment to meet the needs of the office. In the longterm, reducing stress through these practices can lead to many cost-saving benefits: higher productivity and lower turnover and absenteeism.

Prevention cont.

Radiation

It is unknown whether there is a VDT radiation hazard. Yet given the uncertainty, it is advisable to err on the safe side and take reasonable precautions. The following practices would reduce any existing hazard: • regularly service terminals to prevent any unusual emissions resulting from malfunction; • design jobs so employees are not required to sit in front of a VDT all day long; • enable pregnant women to transfer to a non-VDT job with no loss of pay, if they choose; • only purchase equipment which has been factory tested for radiation emissions; • consider screening to reduce emissions of non-ionizing radiation.

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VDT Checklist

VDT Workstation

Does the VDT have:

- ☐ a detached keyboard
- ☐ non-glare glass (or an effective glare shield)
- ☐ brightness and contrast controls
- ☐ adjustable tilt
- ☐ adjustable height
- ☐ characters which are large and sharp enough to read easily
- ☐ no visible flicker

- ☐ Is the VDT quiet, that is, no annoying or high pitched humming?
- ☐ Is the VDT regularly cleaned and serviced?
- ☐ Has the VDT manufacturer provided information about radiation levels measured during factory testing?

Does the desk have:

- ☐ a lower, adjustable surface for the keyboard and a higher surface for the screen
- ☐ enough space for the materials worked with
- ☐ enough space so the screen is at a comfortable viewing distance (1-2 ft.)
- ☐ a non-glare finish

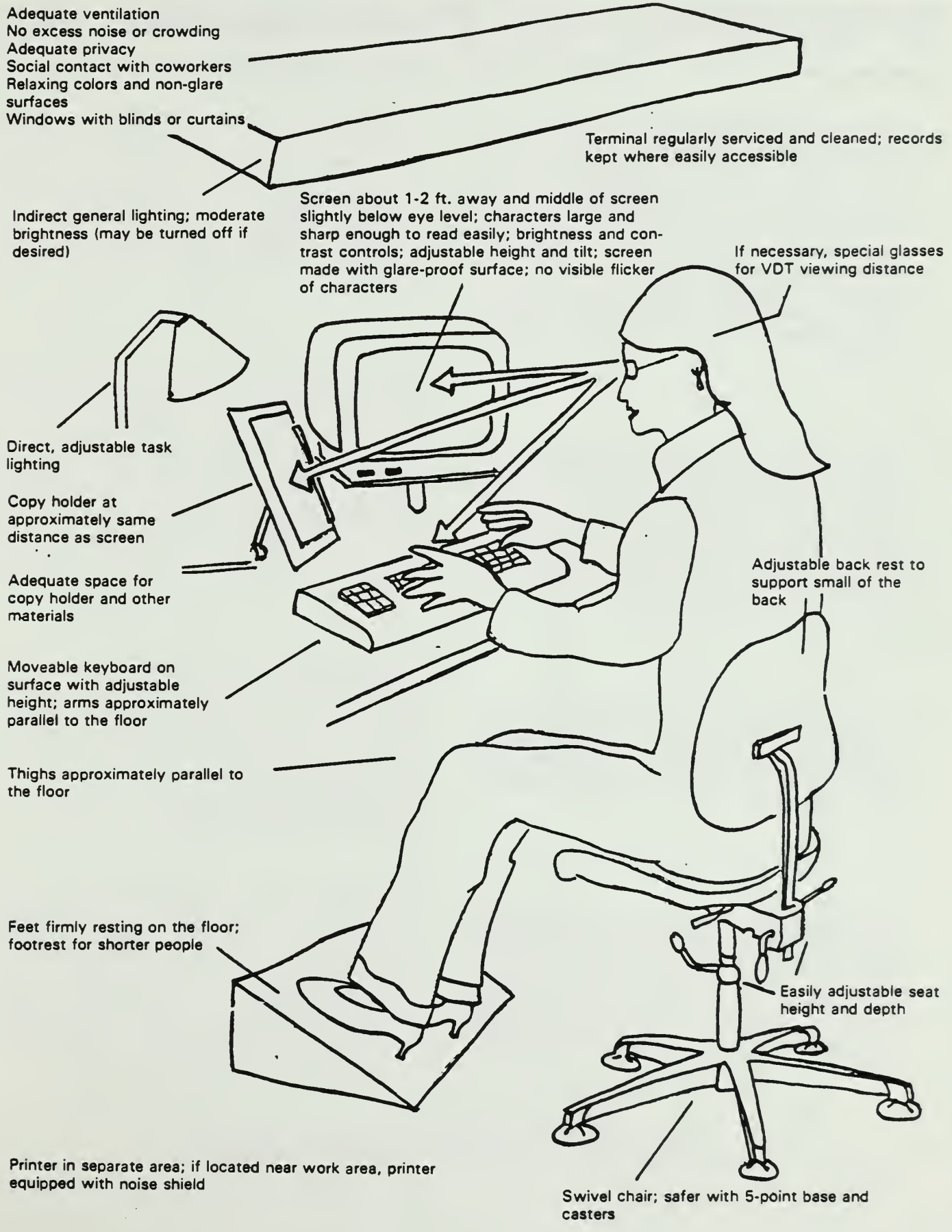
- ☐ Is a copy holder available?
- ☐ Is the chair easily adjustable for height and back support?
- ☐ Have the overhead lights been dimmed and a desk lamp provided?
- ☐ Do the windows have blinds or curtains?
- ☐ Are noisy printers in a separate area? If not, are they covered with noise shields?

Job Design

- ☐ May users take rest breaks every hour from intensive VDT work?
- ☐ Do jobs require a variety of duties on and off the VDT?
- ☐ Most days, may VDT users keep the number of hours at the VDT under four?
- ☐ Do users receive thorough training on the VDT?
- ☐ Do job descriptions accurately reflect the work done on VDTs?
- ☐ Is there enough VDT equipment to meet the needs of the whole office?
- ☐ Are users asked to participate in decisions about how new systems will be implemented?
- ☐ May users choose not to work on a VDT during pregnancy without loss of pay or job seniority?

A Model VDT Work Station

- Adequate ventilation
- No excess noise or crowding
- Adequate privacy
- Social contact with coworkers
- Relaxing colors and non-glare surfaces
- Windows with blinds or curtains



Terminal regularly serviced and cleaned; records kept where easily accessible

Indirect general lighting; moderate brightness (may be turned off if desired)

Screen about 1-2 ft. away and middle of screen slightly below eye level; characters large and sharp enough to read easily; brightness and contrast controls; adjustable height and tilt; screen made with glare-proof surface; no visible flicker of characters

If necessary, special glasses for VDT viewing distance

Direct, adjustable task lighting

Copy holder at approximately same distance as screen

Adequate space for copy holder and other materials

Adjustable back rest to support small of the back

Moveable keyboard on surface with adjustable height; arms approximately parallel to the floor

Thighs approximately parallel to the floor

Feet firmly resting on the floor; footrest for shorter people

Easily adjustable seat height and depth

Printer in separate area; if located near work area, printer equipped with noise shield

Swivel chair; safer with 5-point base and casters

Widespread Agreement: Prevention and Participation Key

"Obviously, the design of office technology has a great impact on the nature of work in the office. It is for this reason that the new relationship requires considerable influence by employees on the design of that technology, well before vendors have been selected and while there is still room to influence the type of work system that will emerge. . . . The results for companies moving in this direction will be greater productivity, improved quality, and increased employee satisfaction." *(Michael Beer, Harvard Business School and Bert A. Spector, Northeastern University)*

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"Our society is technologically advanced. We put people on the moon; we build nuclear arsenals able to destroy the world many times over; we've got typewriters that listen and telephones that see. Surely we can reach the relatively smaller goals of building safe machines, designing good jobs, providing for career advancement, increasing productivity, and preventing job loss." *(Karen Nussbaum, 9 to 5)*

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"Human energies should go into the task at hand, not into finding a comfortable position. Equipment should be adjustable to people's needs, not the other way around." *(Canadian Business Equipment Manufacturers Association)*

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"Scientists have now accumulated a body of data that makes it possible to weigh the health risks of the office revolution. For now, effective computer application appears to depend chiefly on the employer's willingness to provide a comfortable workplace, and insofar as possible, meaningful duties." *(Elizabeth Whelan, Executive Director, American Council on Science and Health).*

"Several things should be considered to promote the healthy and safe use of visual displays: • individual physiological and anthropometric requirements of users; • task design to satisfy user needs; • accommodation of workplace and task for user satisfaction; • careful introduction and management of change; • emphasis on the system as a positive enhancement to our human capabilities." *(IBM Corporation)*

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"In the final analysis, the strongest incentive to improve office working conditions is productivity. The enhanced productivity promise of office automation may be largely defeated or greatly improved by the working environment provided to users. Given the situational nature of some of the hazards, employee involvement in problem identification and solution may ultimately be the most effective avenue to address and solve these concerns." *(Robert J. Smith & Anita W. Shoomaker, Attorneys, Washington, D.C.)*

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"Along with the benefits, VDTs have resulted in some problems. Sore eyes. Aching back and shoulders. Neck pain. Those problems are reducing organizational effectiveness, raising absenteeism, increasing turnover, and preventing organizations from getting their money's worth from their VDT investment. . . Fortunately, there are solutions. . ." *(Computer and Business Equipment Manufacturers Association)*

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"Those who plan for the implementation of automation can show their respect for us by designing systems that will free office workers from monotonous and boring tasks, and by allowing for the full utilization of our skills and intelligence. This technology does have the capability of freeing us from office drudgery. I hope we have the sense to utilize that capacity to the fullest." *(Mary Mitchell, Boston office worker; member, 9 to 5)*

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